

POWER TRANSMISSION DESIGN

SEPTEMBER 1961

INCLUDING BEARING DESIGN APPLICATION

Shaft shattered after three hours
of tortuous torsional vibration
see contents, page 5



FIRST OF A SERIES ON:

TORSIONAL VIBRATION

WHAT IT DOES

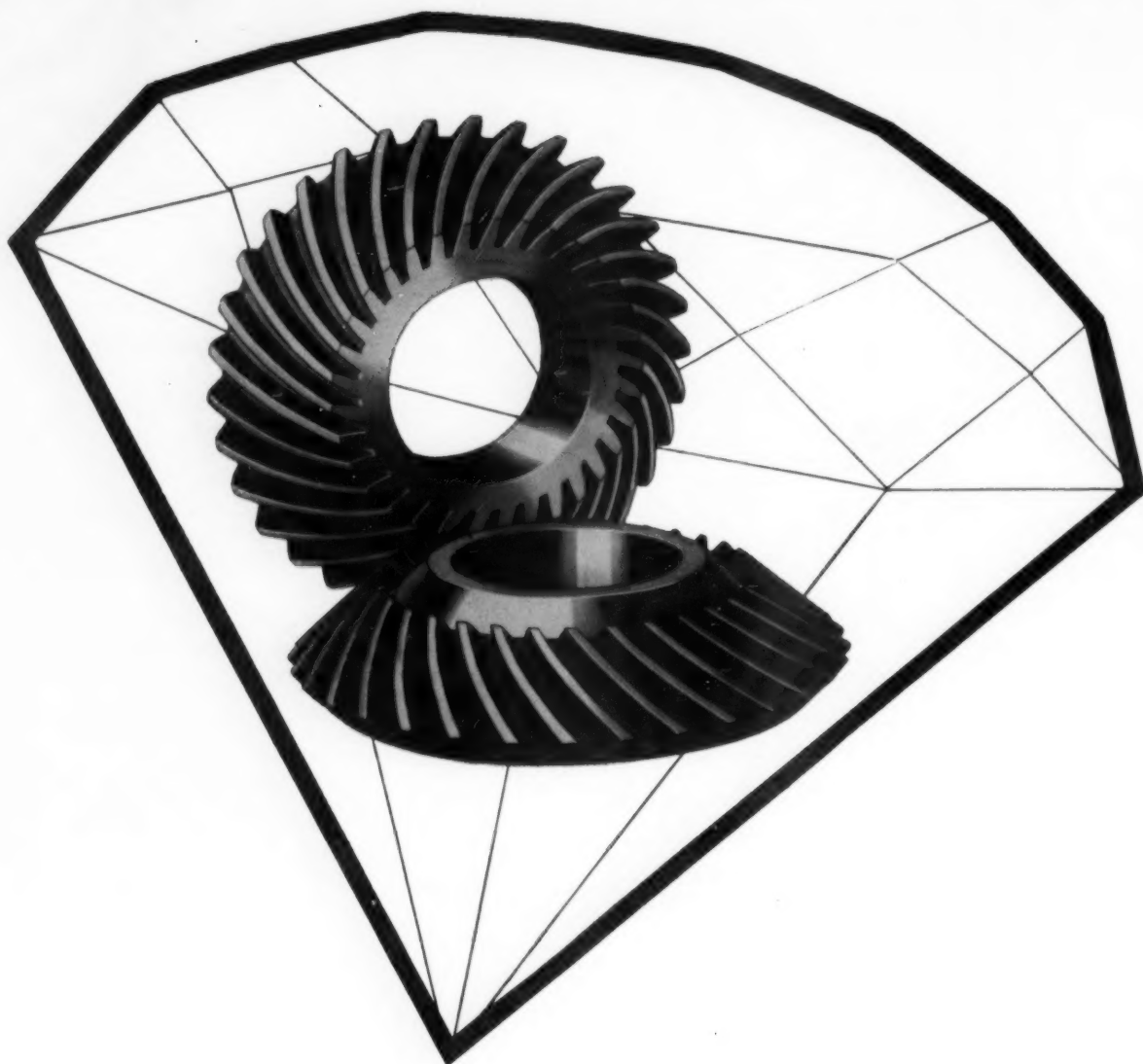
HOW TO LIMIT IT

ALSO IN THIS ISSUE

- ▶ Tractor drive designs emphasize power and simple control
- ▶ Quick and accurate indexing when clutch and brake interact
- ▶ Trouble shooting guide for manually operated transmissions
- ▶ Which bearing was that?

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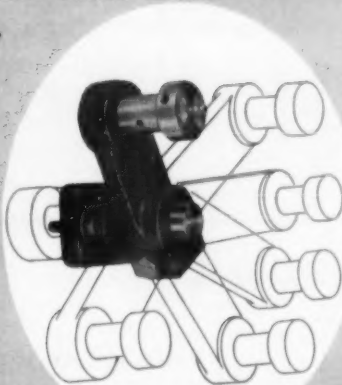
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4 types of idlers

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bronze bearings, wide range of diameters



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Sprockets for chain drives



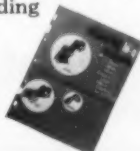
V-Drive pulleys



Flat Belt pulleys

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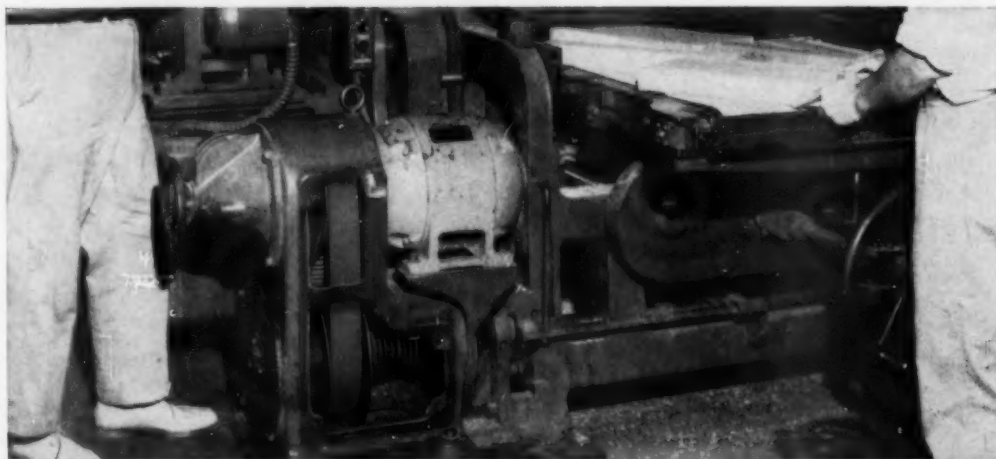
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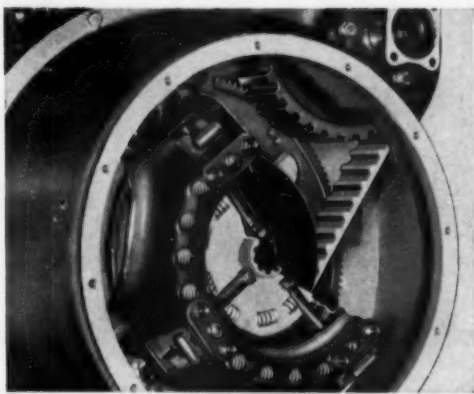
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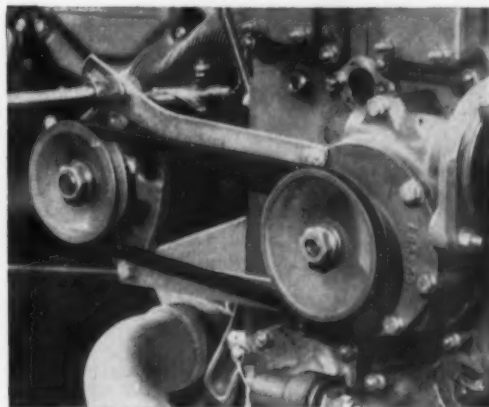
VSB 102

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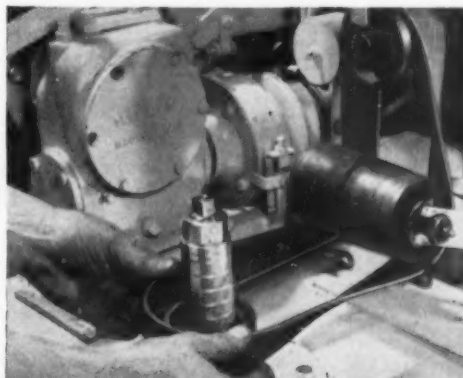
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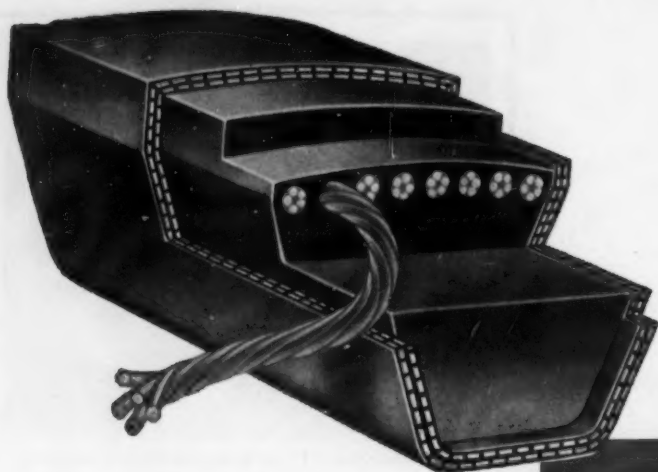
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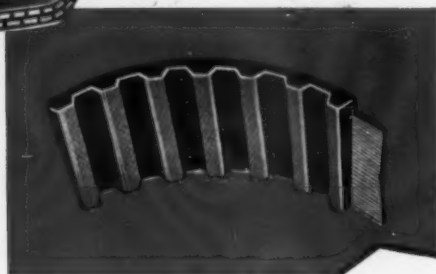


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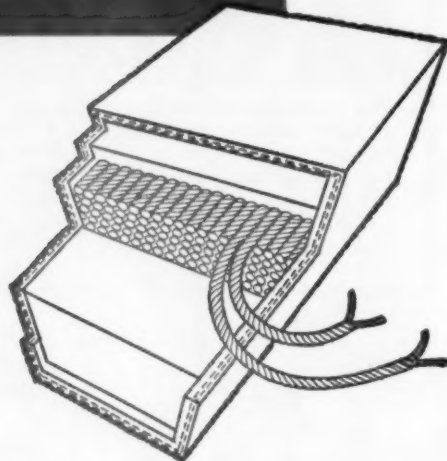
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THE MAGAZINE FOR MACHINE DESIGNERS

SEPTEMBER 1961

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volume 3 number 9

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3.2	80 lb.-in.	2 3/4"	1 1/2"	90	9.6	3 lb.
3	60 lb.-in.	2 1/4"	1 1/2"	90	5.7	2 1/2 lb.
2.5	30 lb.-in.	2 1/4"	1 1/2"	90	5.3	1 1/2 lb.
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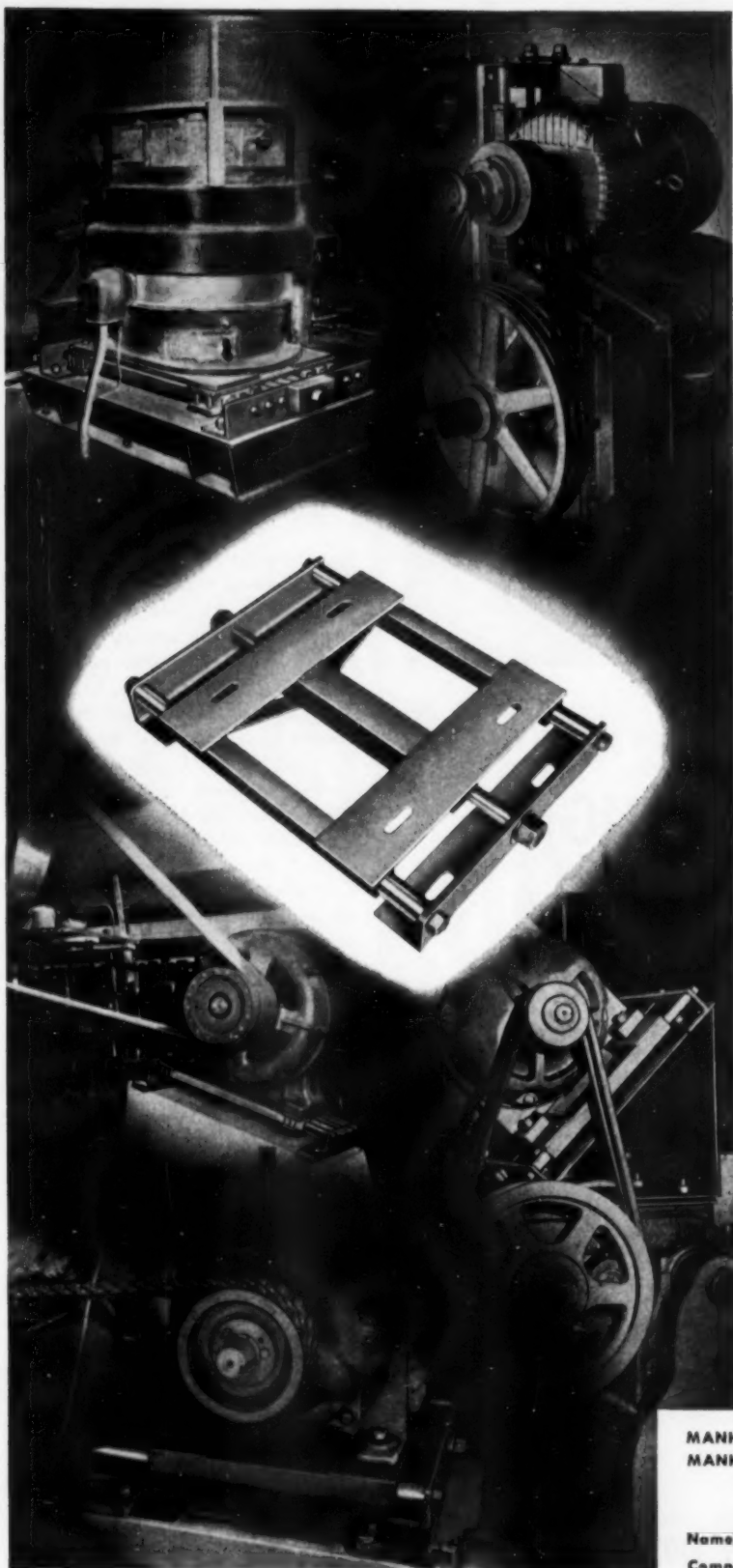
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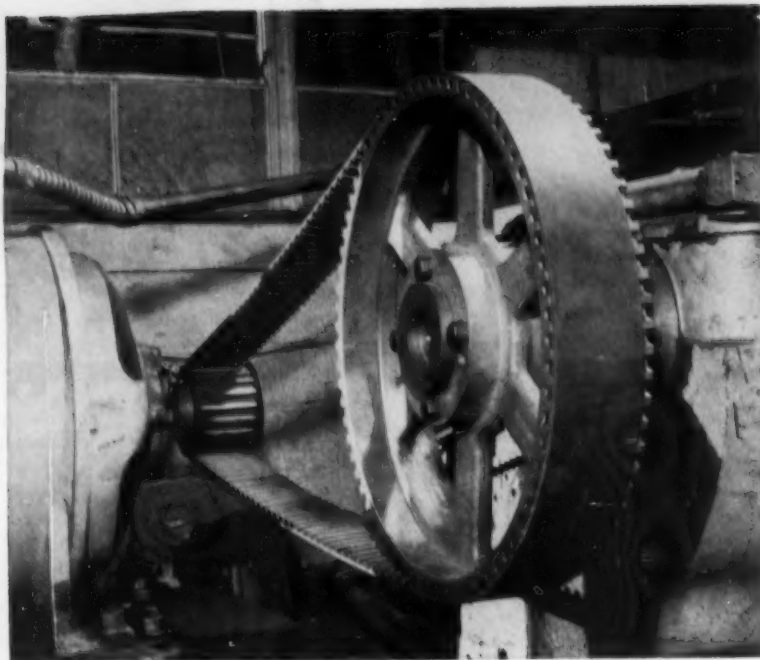
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LETTERS

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We would also suggest that you contact the author of Planetary Gear Trains, p 21 in our June issue, and the many companies who contributed to the article on tractor drives, on p. 24 in this issue.

Belt Drive Guide Corrections

The following omissions should be corrected in the Belt Selection Guide, August issue, pages 28 & 29:

Flat belt manufacturers—Include Raybestos-Manhattan's Rubber Div. under rubber and fabric belts.

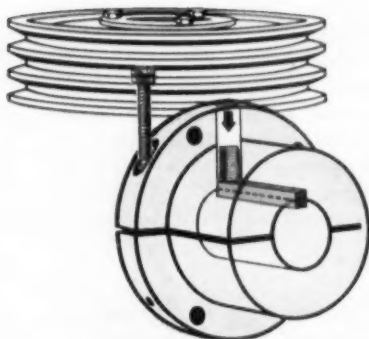
Flat Belt pulleys—Include Browning Mfg. Co.

Multi-V (ribbed) belts—The only companies who presently produce this type of belt are Raybestos-Manhattan, Goodyear, Dayco and Browning.

Controllable speed belts—Include Browning Mfg. Co.

Conventional section V-belts—Include Gates Rubber Co. and Browning Mfg. Co. The controllable speed belt shown on page 22 is made by Maurey Mfg. Corp. and not Lovejoy Flexible Coupling Co. as stated in the caption.

"AND THEN THE KEY CAME LOOSE..."



"Well, the key broke a window—it could have killed someone. A shaft was scored . . . the loss of drive power resulted in a loss of material . . . over \$1,000 . . . we had to postpone deliveries 4 days." Frankly, this plant manager had it rough . . . though it could have been a lot worse, too. But he could have avoided the trouble completely by using Worthington sheaves that have the Two Golden Screws.

The Golden Clamp Screw at the left is an exclusive Worthington feature that locates and locks the hub securely on the shaft, permitting you to tighten the set screw without distorting the hub. And note that the two-piece hub-and-rim design simplifies installation. You install one piece at a time—or change sheaves without disturbing the hub or affecting the alignment.

The Golden Screw on the right is the set screw that turns down to lock the key securely in place. It prevents potentially damaging key drift. There's no extra cost for the set screw but it is worth its weight in gold for the safety it provides.

These Worthington hubs are standard in three major Worthington drive systems: the new, money-saving, more compact Multi-Wedge Drive; the standard Multi-V Drive and the Positive Drive. Ask for one or more of the "how-to-figure-it" design manuals shown here. Your local Worthington distributor stocks these products. He's listed in the Yellow Pages. Or write Worthington Corporation, Section 79-42, Oil City, Pennsylvania.



Multi-V



Multi-Wedge



Positive Drive



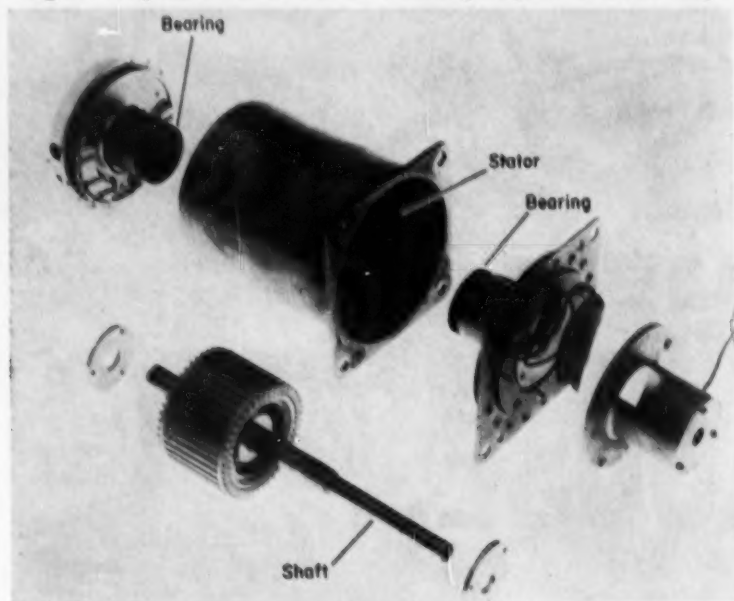
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NEWS

from the power transmission field

High temperature motor uses graphite bearings



Problems of design and materials must be faced when a 5-hp ac aircraft motor has to work at 80,000 feet and ambient temperatures to 600 F. The AiResearch Mfg. Co. found one of the most

difficult problems was to find a suitable bearing. With continuous duty rating and no lubricant or external cooling the motor bearings have to withstand temperatures of 870 F. Rated output torque is 3 in. lb, with a 3 lb thrust load and 10 lb radial load.

Solution was to use three piece radial segment bearings of carbon graphite material. To overcome the relatively low tensile strength, the bearings have an unconventional mounting that obtains maximum use from the material's high compressive strength. The graphite segments were shrink-fitted in place to keep the bearings in constant compression. A length-to-width ratio of more than two to one distributes the high radial load. Precision boring of the bearings took place after first as-



sembling the motor housing, end bells and bearing segments. To prevent galvanic action between bearings and motor shaft which occurred during humidity tests, the shaft bearing surfaces were flame-plated with aluminum oxide.

The motors successfully passed a series of tough tests for MIL specifications. These included dielectric, acceleration, shock, vibration, humidity and load tests. The graphite bearings are Graphitar 2490, a material made by the United States Graphite Co.

Pinch plasma engine contract to Republic

The Air Force has awarded a \$193,900 contract to Republic Aviation to build a compact, battery powered pinch plasma engine.

Details are classified, but company spokesmen expect the engine will develop greater thrust than any other electrical propulsion system under development. It will be a completely packaged unit with its own fuel supply and cyclic pulse rates up to 600 times per minute.

This type of engine uses readily available inert gases for fuel. The fuel becomes ionized after injection into the engine and the resultant plasma is electromagnetically accelerated and exhausted at velocities of over 100,000 mph and temperatures around 200,000 F. Metal wall temperatures, however, remain relatively cool at 200 to 300 F, so there's no need of auxiliary cooling. There are no moving parts.

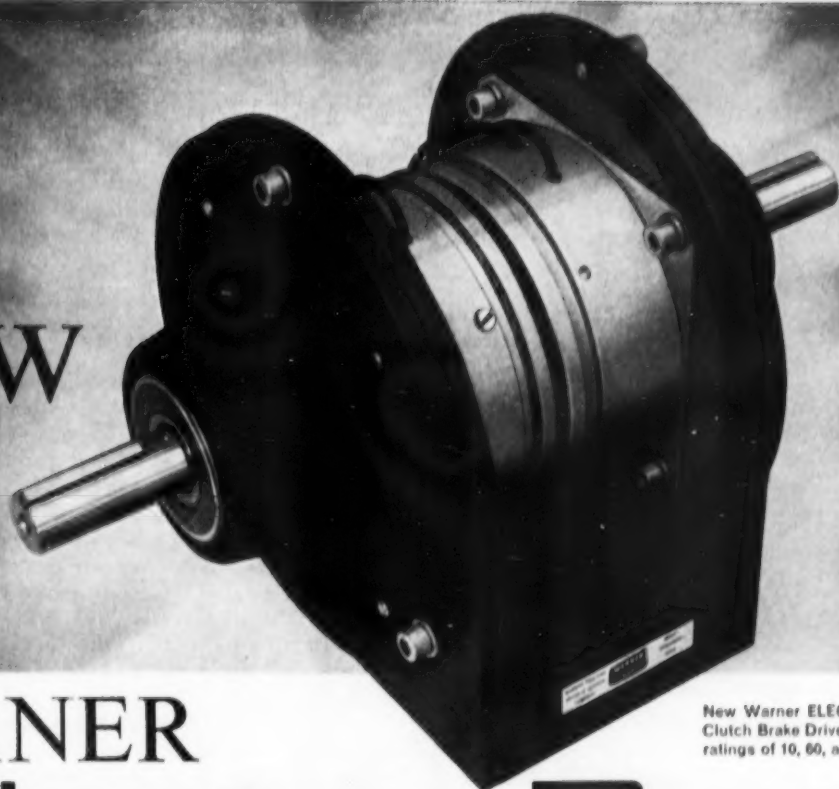
Prior to the contract award, Republic demonstrated an experimental model—the third version of the plasma engine built by the company since 1957—at the propulsion lab of the Aeronautical Systems Div. at Wright Field.

Convention is "graduate school" for industry

The Mechanical Power Transmission Equipment Distributors Association will hold its annual convention October 23, 24, and 25 at Chicago's Edgewater Beach Hotel.

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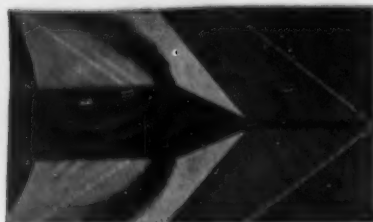
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Circle 125 on Reader Service Card

NEWS

sociation as the "graduate school" for distributors and manufacturers. Convention Committee Chairman Wayne A. Bodine points out that the meetings, panels and services will be comparable to the best graduate schools in the U. S. In the interchange of ideas methods

and problems "distributors and manufacturers become better informed, better educated and better prepared to make a larger profit."

Registration fee is \$45 each member, \$60 non-members; registration forms from MPTEA, 1028 Connecticut Ave. N. W., Washington 6, D. C.

Wire numbering machines will save \$70,000

Five automatic wire numbering machines will replace the seven numbering machines now used at Lockheed Aircraft's California Div. in Burbank. Savings estimated for first year's operations: \$70,000 plus. No companion linotype machine is needed. Numbers and letters are dialed directly on steel discs which maintain printing temperature. Printing pressure is gradual and adjustable rather than impact, saving machine wear.

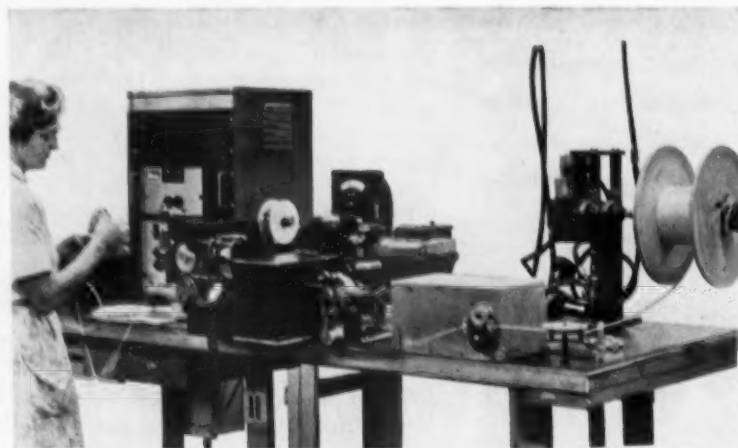
An "electronic brain" controls spacing of numbers, quantities of wires, and cut-off cycle. The machine itself is powered by a single electric motor driving a shaft through a sprague clutch. One takeoff from this shaft is geared to the machine; another drives the puller through an electronically

timed magnetic clutch. This synchronizes puller and machine.

The new design "flip-flops" the wire to print on each side alternately, thus saving one complete set of type and one roll of marking foil. The flipflop is run from an air cylinder through a rack gear and pinion and is also timed electronically from the machine.

The machine takes all sizes and types of wiring from miniaturized 22 gauge and standard 10 gauge to heavy coaxial cable. Present rate is 646 in. per minute. This performance will be bettered with the development of a device to coil wire automatically after printing. IBM card control is projected for the future.

Lockheed designed the machine, American Pacific Stamp Co. will make and sell it.



Competitive job market for engineers

The 1961 engineering job market is "cautious and competitive", according to John A. Bornemann, placement director of Columbia

University. Company representatives had fewer jobs this year for Bachelor's and Master's candidates in electrical, mechanical and

in machine design or modernization...

Fawick
FSPA
improves
machine
performance

...with increased production through higher machine speed
Fawick Standardized Press Applications may be used as original equipment or for modernization on power presses and other machinery where productivity depends on cycling speed. Instant air clutch action and fail-safe braking allow faster operation without sacrificing safety or precision.

...precision control

FSPA provides split-second starts and stops that assure accurate automatic control of single, continuous or inching operations.

...manpower and machine protection

FSPA eliminates damaging backlash, providing maximum protection for intricate tooling. The spring-applied brake engages immediately in case of air or power failure, preventing costly jamming and insuring operator safety.

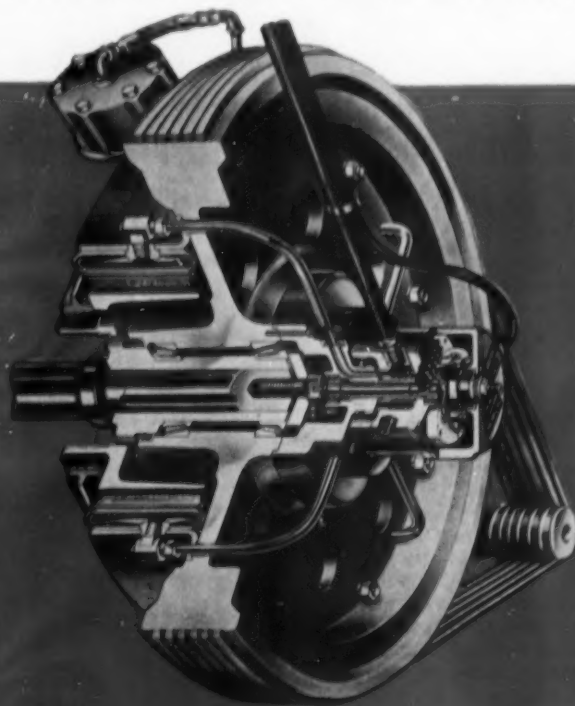
...installation flexibility

FSPA can be installed quickly and easily in both OEM and user applications. The package unit may be mounted on a common drum as shown below, or the brake may be mounted at another location on the shaft. Installation can be made with only minimum preparatory work.

...and unmatched low maintenance

Fawick drum-type air clutches have few moving parts and require no lubrication. The self-adjusting 360° friction surface insures long friction life and continuous new unit performance under the most demanding conditions.

FAWICK STANDARDIZED PRESS APPLICATION includes constricting type CB Airflex Clutch, spring applied CS Brake, Timing Rotorseal and high-speed clutch control — designed into a package unit which meets the toughest requirements for fast, accurate power transmission. FSPA is produced in 26 standard sizes with torque capacities from 2,040 to 172,000 in.-lbs. at 75 psi.



For complete information on how Fawick can simplify your clutch problem, contact your nearest Fawick representative or the Home Office.

FAWICK AIRFLEX DIVISION
FAWICK CORPORATION

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Fawick Canada, Ltd., 60 Front St., West, Toronto, Ont., Canada



INDUSTRIAL CLUTCHES AND BRAKES

Circle 42 on Reader Service Card



Photo courtesy Cushman Motors

R/M found friction material answers for versatile Cushman Trailster

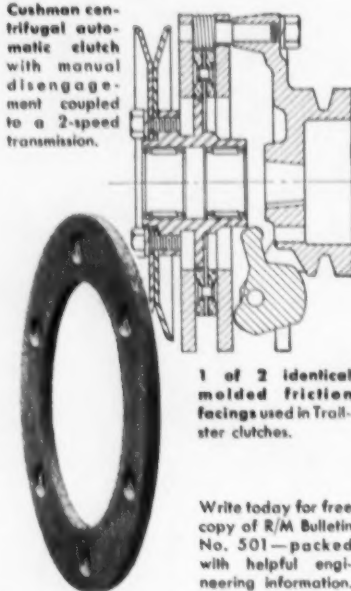
"We placed our friction problems for the Trailster's centrifugal automatic clutch in Raybestos-Manhattan's hands," says R. D. Von Seggern, assistant chief engineer, Cushman Motors, Lincoln, Nebr.

"Cushman has been using Raybestos-Manhattan friction materials in various models of utility vehicles for over 15 years. Based on past experience, we know we can rely on them for assistance at every stage—from design to production.

"We needed a friction material capable of withstanding high heat generated by slippage until the centrifugal clutch engaged. It had to have a uniform coefficient of friction over a wide temperature range and low wear characteristics. R/M was able to develop a molded material which meets these requirements."

Why not take a tip from Mr. Von Seggern—call on us and make use of our knowledge of friction accumulated from 50 years of experience. Just phone or write—a sales engineer can be at your desk within 24 hours. Remember . . . only R/M makes all types of friction materials; your assurance of unbiased council.

Cushman centrifugal automatic clutch with manual disengagement coupled to a 2-speed transmission.



1 of 2 identical molded friction facings used in Trailster clutches.

Write today for free copy of R/M Bulletin No. 501—packed with helpful engineering information.



RAYBESTOS-MANHATTAN, INC.

EQUIPMENT SALES DIVISION: Bridgeport, Conn.

Chicago 31 • Cleveland 16 • Detroit 2 • Los Angeles 58

Circle 85 on Reader Service Card

NEWS

industrial engineering. There was little change from last year for graduates in chemical engineering and engineering mechanics. There were more jobs for civil engineers.

For the first time in five years salaries failed to advance. The median monthly salary for a new BS was about \$540. An MS could expect about \$600 a month. The outlook for PhD's in engineering was good, with salaries ranging from \$750 to \$800 a month and strong demands for mathematicians, chemists and physicists.

Gyroscope ball will spin in space

The heart of a new inertial guidance system will be an ultra precise metal ball suspended in a gyroscope by a magnetic field and spinning in a vacuum at temperatures near 460 below zero F.



The ball—worth more than 30 times its weight in gold—is cut from a solid bar of columbium. It weighs only 3½ oz and columbium (a gray soft metal) is about \$80 a pound. The value comes from the extreme degree of finish—to a roundness tolerance of 10 millionths of an inch. Shaping the ball took three months and was such a delicate operation that the heat of the human body drawing near it was enough to cause a measurable distortion.

The extreme cold around the sphere is necessary to make the

POWER TRANSMISSION DESIGN

New ROTO- MISSION®



**Most versatile
transmission
ever developed!**

**ONLY ROTO-MISSION GIVES YOU
ALL THESE FEATURES**

- Concentric configuration
- Minimum size for a specified torque
- Reduction ratios up to 270:1
- Optional torque capacities for each reduction ratio
- Torques up to 21,850 lb.-ft.
- Requires neither driving pulley nor coupling
- Casehardened helical gears—ground after hardening for perfect engagement
- Reversible
- Progressive overload capacity to the extent that no breakage of gears can result even from the severest abuse
- *Ability to engage or disengage driving action—mechanically, pneumatically, hydraulically or electrically
- *Ability to provide load releasing, load limiting or overload alarm
- *Ability to provide 2-speed operation

*Standardized accessories to provide these features are available for all sizes of Roto-Mission from stock. This results in a single responsibility for installation performance.

This new rotary transmission design combines a wide range of reduction ratios, high torque capacities, and excellent space-saving characteristics to give you more application versatility than ever before possible. It is designed to be concentrically mounted on a machine drive shaft in place of the drive pulley and operate this shaft at a reduced speed from that of the driving motor. For maximum compactness and convenience, all its parts are inside the casing.

The standard accessories available for each model of Roto-Mission add even greater versatility. Through them you have systems—from a single source—capable of control functions that previously required a number of unmatched units from several suppliers.

Because of its versatility and sound engineering, Roto-Mission permits you to solve design problems far beyond the range of other transmissions—may even permit incorporation of features in your machines that have not previously been possible. For complete information on this new product—how it operates and how it can help you—write today for catalog IR-61.



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IDEAL FOR AUTOMATED MACHINES

FAST
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SELF
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Maxitorq

ELECTRIC

CLUTCHES and BRAKES

Incorporating advanced design principles proved through years of service, the MAXITORQ Electric Clutch is well adapted to all types of machine drives. Simple in design . . . built to machine tool standards . . . requires no adjustments, can be used either as a clutch or brake. Disc separators not only separate discs, but also break up residual magnetism and result in extremely fast, positive action with no drag or heating in neutral. There are few moving parts. Electrical operating unit remains stationary — hence, no troublesome slip rings, brushes, or difficult wiring problems. Operation is on standard 100 V a.c. Other voltages on special order.

If you have a clutch or brake application where you are looking for NEW and IMPROVED performance, we invite you to bring the problem to us. Phone, wire, or write Dept. PT for Bulletin No. 90.

SPECIAL FEATURES

Engaged entirely by
magnetic flux.

Operate either on-off or by
varying voltage for torque control.

NO troublesome slip rings
or brushes.

NO levers, cams, or other highly
stressed mechanical parts.

Operation is not dependent
upon rotation.

Finished complete, assembled,
and ready to install on shaft.



THE CARLYLE JOHNSON MACHINE CO.
MANCHESTER, CONN.

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NEWS

columbium superconductive. It then loses all resistance to electricity. Liquefied gases, including liquid helium, bring temperatures to near absolute zero. The ball will be separated by less than paper thin clearances from the wall of the vacuum housing in which it rotates.

With friction from gases or metal contact all-but eliminated, the ball should be able to spin freely for months or perhaps years after once being set in motion.

The General Electric Co.'s Ordnance Department is under contract for this project with the Marshall Space Flight Center.

Detroit Metal Show to have Materials Comparison Center

Focal point of the Detroit Metal Show (Cobo Hall, Oct. 23-27) will be the ASM Materials Comparison Center, a 12000 sq ft area that presents seven engineering material groups for property comparison and evaluation. Scores of sample parts, test specimens and graphic materials will dramatize the presentation.

The ASM sponsors expect one of the greatest concentrations of materials and processing companies in the 43-year history of the Metal Show. A brochure giving advance information on technical sessions and listing the majority of the exhibitors is available free from American Society for Metals, Metals Park, Ohio.

MEETINGS

SEPT.

11-15 Society of Automotive Engineers, National Farm, Construction, and Industrial Machinery Meeting, Milwaukee Auditorium, Milwaukee.

14-15 American Society of Mechanical Engineers—American Institute of Electrical Engineers, Engineering Management Conference Roosevelt Hotel, New York.

18-22 Instrument - Automation Conference and Exhibit, New York.

POWER TRANSMISSION DESIGN

THE ORIGINAL
AND EXCLUSIVE
"CONCENTRIC" SHAFT KING



THE NEW
"OFFSET" SHAFT KING



First and Still the Finest SHAFT-KING Speed Reduction Drives by



In the popular SHAFT-KING SPEED REDUCTION DRIVES, American Pulley offers you the world's most complete line of shaft-mounted reducers. Whatever your application, you'll find a SHAFT-KING DRIVE to suit it perfectly: from F HP to 60 HP . . . in 5:1, 13:1 and 20:1 ratios . . . and for any drive speed from 5 to 350 RPM. SHAFT-KING SPEED REDUCTION

DRIVES are *performance-proved*, too. Since 1941, when American *pioneered* the shaft-mounted reducer, over 150,000 SHAFT-KING DRIVES have been installed.

Whatever your power transmission problem, there is a standard American Pulley product—or one can be designed—to solve it. Call your American Pulley salesman.



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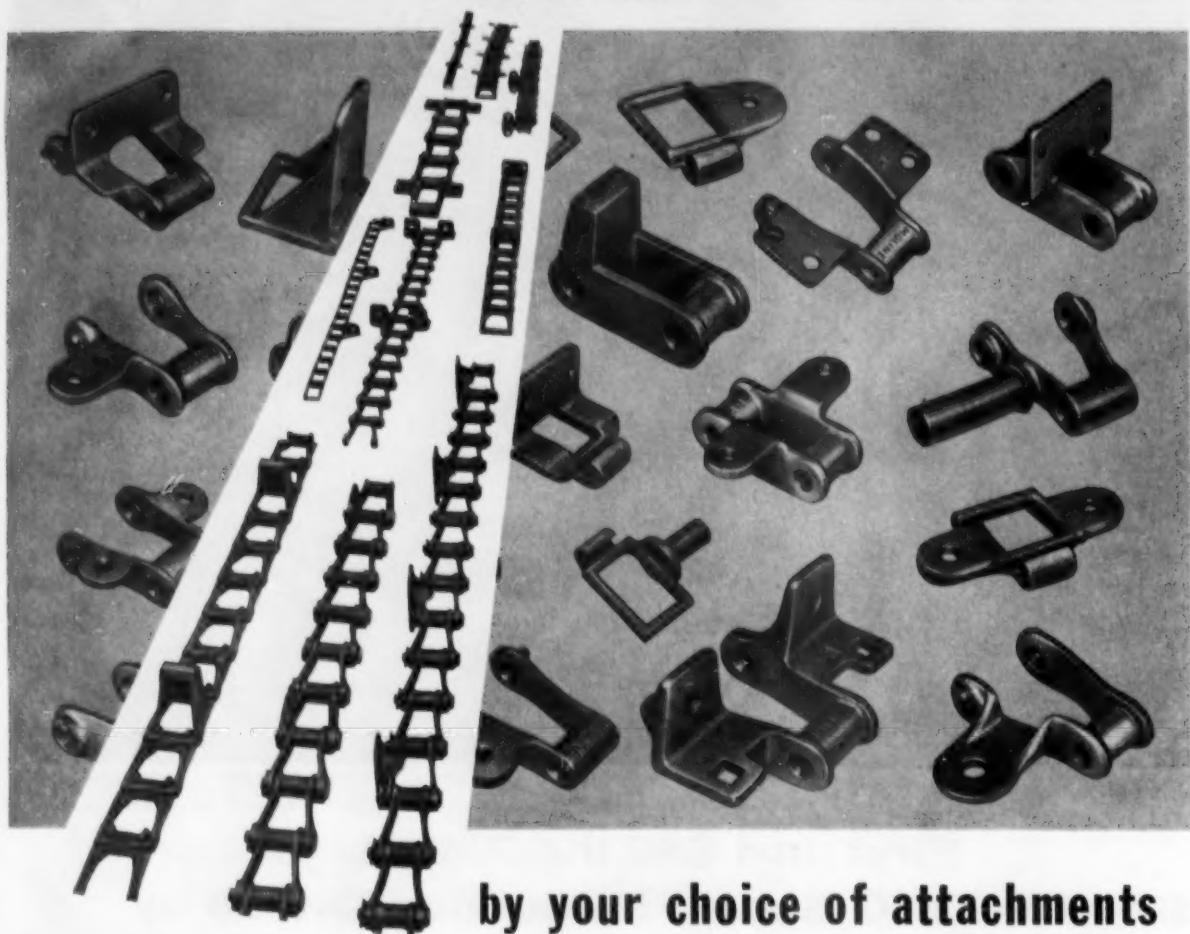
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1000-A

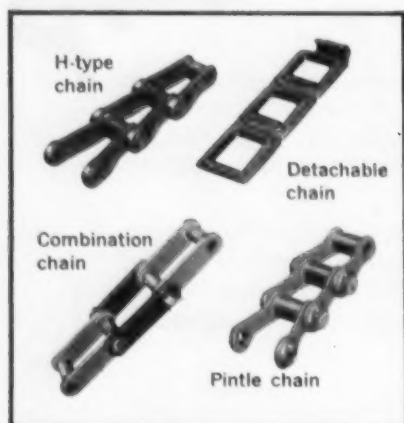
September, 1961

17

Moline Chains become freight trains



by your choice of attachments



Put on your imagineering cap and you'll see scores of conveyor ideas in the representative group of Moline chains and attachments shown here... ideas for lifting or lowering, pushing or pulling, scraping or dragging—for every kind of material handling you can think of.

Choose the attachment that solves your conveyor problem. There are hundreds of working combinations utilizing standard chain and attachments that are available in stock. If you don't see the right chain-attachment combination above, ask for the new Moline Design Engineers' Handbook. This new book lists all types and sizes of Moline Chains and attachments and provides hundreds of suggestions on applications and operation. Write for your copy today. And if your problem calls for "special" chains or attachments, consult Moline's engineering service.

*Specializing in the
manufacture of chains*

Moline authorized distributors
are located in all industrial
areas and principal cities.

Moline Chains

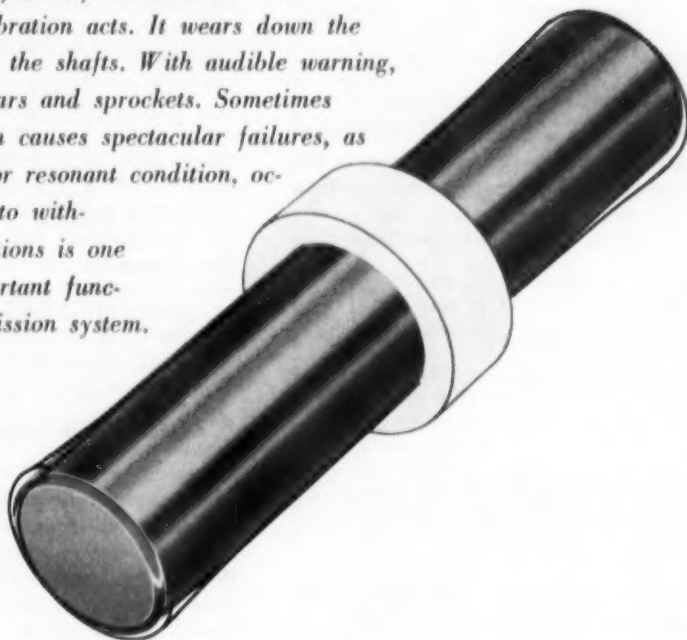
for conveying, elevating and power transmission

MOLINE MALLEABLE IRON COMPANY

St. Charles, Illinois

Circle 75 on Reader Service Card

Even the smoothest source generates power in pulses. From this all torsional vibration stems. A faint imbalance in the system, or even the mass at the other end of a shaft can be the lever through which vibration acts. It wears down the bearings, fatigues the shafts. With audible warning, it hammers at gears and sprockets. Sometimes torsional vibration causes spectacular failures, as when a critical, or resonant condition, occurs. Being able to withstand these vibrations is one of the most important functions of a transmission system.



TORSIONAL VIBRATION

By T. W. SPAETGENS, Consulting Vibration Engineer, Toronto, Canada

PART 1—Fundamentals

TORSIONAL VIBRATION is undoubtedly the largest single contributing factor in failure of power transmission systems. In systems with a strong torsional exciting source, such as the reciprocating engine, failures due to torsional vibration may reach 85 percent. Shafts, bearings, gears, chains, clutches,

belts, and couplings are all frequent victims of torsional vibration.

Fatigue-stress phenomenon

Whatever the failure—a rough roller bearing, a broken or cracked shaft, a badly pitted gear, or a broken chain—fatigue very likely caused it. Torsional vibration induces fluctuating stresses that reduce the fatigue safety below unity. This shortens the fatigue life—sometimes drastically. A component with, say, a 20,000-hr fatigue life under normal dynamic stresses may last only 2000 hr, 200 hr, or even 2 hr, when a high alternating shear

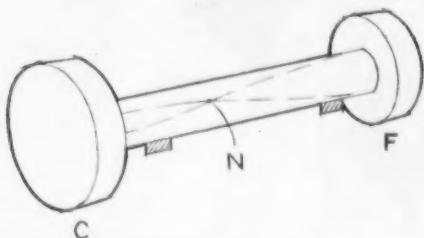
This article, the first in a series of four, explains what torsional vibration is, and what it can do. Later articles will detail how to spot it, methods of dealing with it, and show the damage it does.

stress resulting from torsional vibration is added to the normal dynamic stress.

After looking at some theory of torsional vibration, its effect on fatigue life of shafting, bearings and gears will be considered. At this point, though, it may be stated unequivocally, that a power transmission system which has not been torsionally analyzed is inadequately designed. Torsional vibration is inherent in power transmission systems and it produces extremely high fatigue-producing vibratory torques and stresses in the components. To neglect these factors in design invites failure and unreliability.

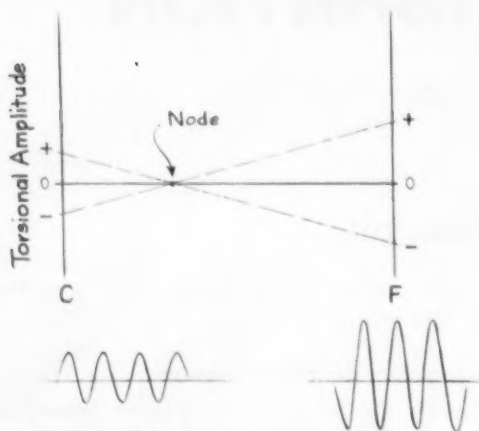
Dynamic response

Torsional vibration becomes important only when some influence is present to excite and sustain the vibration. An extremely important concept in vibra-



SIMPLEST TORSIONAL SYSTEM, the basic 2-mass system. If the masses are twisted in opposite directions and suddenly released, the system engages in torsional vibration.

tion theory is dynamic response. It concerns the manner or degree in which a system responds to impressed dynamic or vibratory torque excitation. Any system will vibrate at the frequency of an



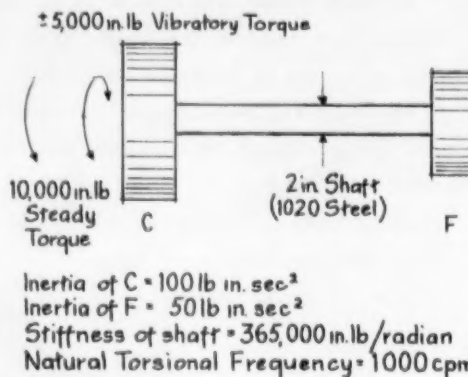
FREE VIBRATORY SHAPE of the basic system above, showing the point of zero vibratory motion, called the node. Note that the amplitude of torsional oscillation of point F is greater than that of C by the ratio NF/NC .

imposed excitation. Its response, however, depends on the ratio of the forcing or exciting frequency to its natural torsional frequency. Severity of the

disturbing torque, and the damping energy available in the system, also affect the response.

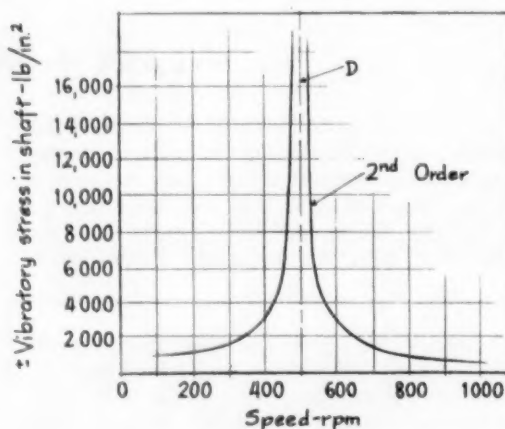
An Example

A steady torque of 10,000 in. lb rotates disc C, makes it do useful work to be absorbed at disc F. A second order vibratory torque of ± 5000 in. lb is also impressed on disc C, with a frequency twice the speed of the system. This forcing frequency vibrates the system at twice its rotational speed. By vibration analysis calculations, the dynamic response



SIMPLE SYSTEM considered in the example has a 2 in. diameter shaft.

of this system is plotted in terms of the vibratory stress imposed in the 2 in. shaft. As the system speed increases, so does the vibratory shaft stress, until the forcing frequency equals the natural frequency. This condition is termed resonant. The system is forced to vibrate at that frequency at which it wants to vibrate (1000 CPM), and it responds sympathetically. The maximum value of the stress, D, is controlled by the damping energy in the steel shaft. As the speed now increases above 500 RPM the applied vibratory torque begins to vary too quickly for the system to follow (since the system wants to vibrate at 1000 CPM). The response falls off with increasing rpm, following exact mathematical



DYNAMIC RESPONSE of the example above.

relationships. Except at the resonant condition, damping forces in the system generally have little influence on dynamic response.

Table I again shows the vibratory stress in the 2 in. shaft at different rpm values. A torque value of 5000 in. lb produces a "static" stress of only 3182 psi, but because this 5000 in. lb torque is alternating, the stress may be increased up to $\pm 50,000$ psi or higher at resonance. At 5 per cent below resonance, it would be 11,072 psi and at 10 per cent below resonance, 5,580 psi. It becomes apparent that there is a very significant fatigue-producing factor in this system. If the shaft happened to run at, say, 475 rpm, its life would be very short. At 500 rpm, (resonance) the shaft would probably last only a few hours.

Now in addition to shaft distress, any accessories driven from C or F, particularly F, could be damaged when the system was operating at or near resonance. Teeth separation and hammering (evidenced by noise and wear on both front and back faces of teeth) would occur at these accessory take-offs. Accessory belt or chain drives would wear rapidly, and may whip and flutter. Quill shafts, flexible couplings, clutches and other accessory-driving components would also suffer. The accessory itself (example, an engine governor) would wear excessively and internal parts might break. The governor might be unstable. Theoretically, the supporting bearings would not be impaired, but in practice the torsional motions can apply fluctuating bearing loads sufficient to produce fatigue. It is also possible that the oil films in sliding bearings will not perform properly because of excessive velocity fluctuations. This overheats the bearings.

The allowable torsional amplitudes for accessory take-off points may vary from ± 0.15 deg to ± 0.50 deg

TABLE I

Vibratory stress and amplitude of 2-mass system with zero damping under influence of 2nd order vibratory torque.

RPM	Vibratory stress in \pm shaft	True torsional vibration amplitude disc C	Rolling amplitude of system	Resultant amplitude of disc C
100	1108 PSI	.092*	-4.353*	-4.261*
200	1260	.102	-1.087	-.985
300	1661	.136	-.483	-.347
400	2958	.243	-.272	-.029
450	5580	.458	-.215	+.243
475	11,072	.909	-.193	+.716
500	RESONANCE			
525	10,753	-.870	-.158	-1.028
550	5008	-.411	-.144	-.555
600	2386	-.196	-.121	-.317
800	681	-.056	-.068	-.124
1000	360	-.029	-.044	-.073

GLOSSARY OF COMMONLY USED TERMS

Torsional Vibration—Angular oscillatory motion (or vibration) set up between any two masses in a system of rotating masses.

Vibratory Amplitude—The largest angular displacement of a mass from its mean position. The angle occurs when the restoring force reaches its peak. At this time the masses are relatively at rest, instantaneously.

Natural Frequency—Number of cycles in a given time, say, per second, at which a system, free from external forces, will vibrate.

Forcing frequency—The frequency of an applied (external) torque causing vibration.

Mode—The manner in which a system vibrates. The lowest natural frequency is the first mode, or manner, the next highest natural frequency is the second mode, and so on.

Node—Any point in a vibrating system at which the amplitude of the angular oscillation is zero.

Resonance—A magnification of vibratory amplitude that occurs when an applied torque of the same frequency as the natural frequency of the system is applied. The resulting torque theoretically tends to infinity, but due to the presence of damping forces, it is limited in practice, to about 100 times the applied torque.

Damping Force—A resisting force which reduces the amplitude of the vibration near a resonant condition. Examples: bearing friction or hysteresis loss in the material.

Equivalent dynamic system—A system of theoretical concentrated masses, or discs, situated at various points along an equivalent straight shaft of circular cross-section, whose torsional properties are the same as those of the real system.

Polar moment of inertia—Rotative inertia, wk^2 .

Torsional Stiffness— K —a physical property of the material of the shaft. Torque necessary to twist a shaft through one radian.

Torque Harmonic—One of several pure sine wave components that make up a torque curve.

Order—The number of cycles of a torque harmonic per revolution of the system.

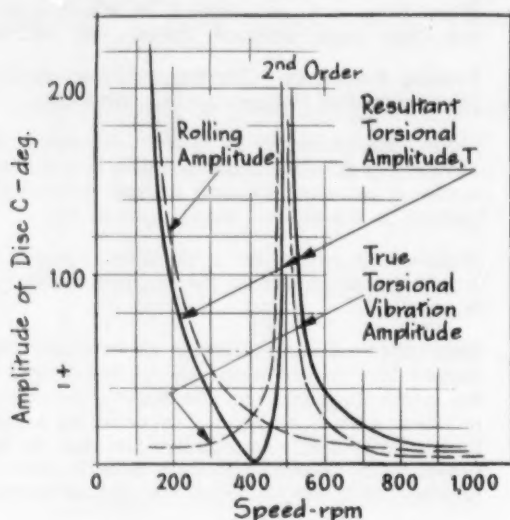
Fatigue—The weakening and ultimate failure of a shaft caused by fluctuation of stresses in it.

Free Vibratory Shape—A curve showing the vibratory amplitudes of various masses in a system, for a particular mode of vibration.

Rolling Amplitude—The maximum (angular) displacement of the whole system without any shaft twisting. Each mass of the system is at rest, relative to every other, under pure rolling. However, rolling is always superimposed on torsional vibration.

depending on the accessory and the vibration frequency. Usually, ± 0.25 deg. is a safe design figure.

The vibratory torque developed by the discs would, in time, damage the keyways or splines connecting the discs to the shaft. Common symptoms are cracking or deformation of the keyway, working of the hub on the shaft (producing discoloration known as "fretting corrosion"), or spline wear. If the discs are fabricated elements, they may be damaged too. Suppose the disc is a generator rotor with windings



SYNTHESIS of rolling amplitude and torsional amplitude for the example considered on page 20.

and damper rings. The rapid oscillations of the rotor can break the damper bars and windings which transmit these velocity changes to the heavy damping ring.

Rolling Amplitude

At low speeds, torsional rolling amplitude becomes a very important consideration in variable speed systems. The vibratory exciting torque of 5000 in. lb. of

our example causes two distinct effects:

1. The torsional vibration already dealt with—which involves shaft twisting and counter oscillation of the discs.
2. Oscillation or rolling of the whole system—which does not involve shaft twisting.

This can be visualized by considering the shaft infinitely rigid so that no torsional vibration can occur. Obviously the system—as one rigid piece—must roll or lope under the alternating torque. The roll frequency, will of course, be equal to the exciting frequency, and its amplitude will be the same for each component of the system. Now torsional vibration effects of 1 are *superimposed* upon this rolling motion. The rolling effect is most pronounced at low speeds where the rotational momentum of the system is low. Rolling amplitude is always anti-phased to exciting torque. Torsional vibration oscillations may be either in-phase or anti-phase depending on whether operation is below or above resonant speed and on which side of the node the disc in question lies. Curve shows the synthesis of the rolling motion and torsional vibration motion is shown for disc C of the system. Curve T is this resultant torsional amplitude, shown in Table I. A recording instrument would pick up the curve T, so that to arrive at the true torsional vibration from recordings involves an accounting of the rolling effects.

Rolling amplitude can inflict damages normally associated with high torsional vibration amplitudes, but at low speeds, even though vibratory stresses in shafting are insignificant. At 200 RPM, for instance, while the vibratory shaft stress is quite low (± 1260 psi) the torsional amplitude of disc C is high enough ($\pm .985$ deg) to damage any accessories driven from this point. Allowable amplitude depends on the frequency of vibration and the nature of the accessory. Fortunately, the forced frequency of low-speed rolling amplitude is fairly low in most power transmission systems, and higher amplitudes can be tolerated.

This article is the first in a series of four on Torsional Vibration. Look for part 2, which covers actual cases of torsional vibration in power transmission systems, in the October issue of POWER TRANSMISSION DESIGN.

FOLLOW-UP BOOKS

This list of standard works on torsional vibration will give you a thorough coverage of the subject.

TORSIONAL VIBRATION PROBLEMS

—by William Wilson

Offers practical solutions of torsional vibration problems, with examples from marine, electrical, aero and automobile engineering practice.

TORSIONAL VIBRATION—by William T. Tuplin

Basic theory and design calculations. A "must."

VIBRATION CONTROL—by John N. MacDuff

Good on solving damping problems.

ELEMENTARY MECHANICAL VIBRATION —by Austin Harris Church

An introduction to simple vibration useful for those wanting a good basis in the subject.

VIBRATION PROBLEMS IN ENGINEERING—by S. Timoshenko & D. H. Young

Standard college work. Good introduction to vibration.

MECHANICAL VIBRATION—by J. P. Den Hartog

A college level book on vibration only.

Rugged washer drive overcomes high shocks

WASHER EXTRACTOR DRIVES are difficult to design because of their unusual speed and load requirements. For example, during the washing cycle alone, they must:

- Transmit torque at the relatively low speed of 20 to 35 rpm, while being subjected to extremely heavy shock loads.
- Stand heavy overrunning loads because of the action of the fabrics as they are picked up and dropped in the washing cylinder.
- Reverse direction of rotation up to four times a minute to keep the wash from being rolled into a ball.

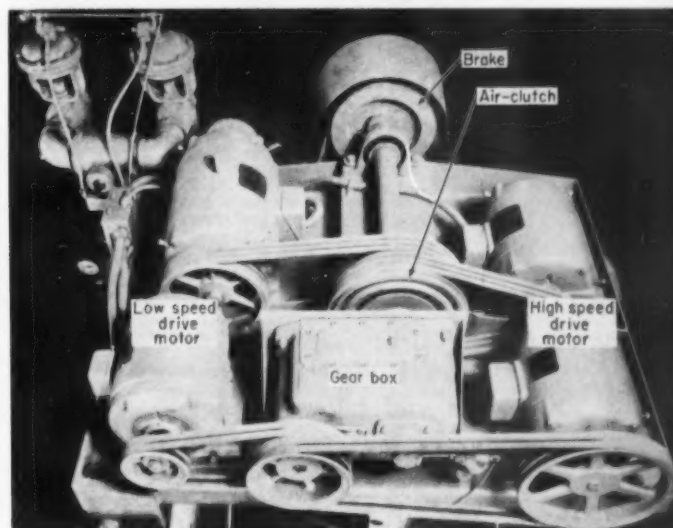
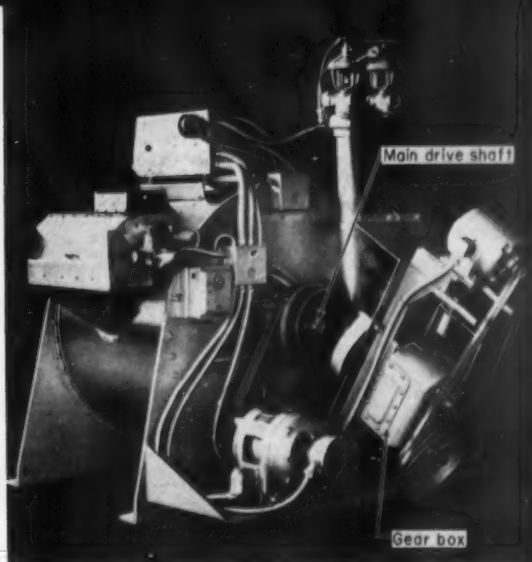
After washing, and during the water extracting cycle, the drive must rotate the cylinder at an increased speed between 600 and 1000 rpm (depending on the machine size).

Still another speed:

In addition to the washing and extracting speed variations, these machines must run at about twice the washing speed, during draining. This speed is used to distribute the wash, and to prevent it from lumping on one side in the cylinder. Any lumping could cause out-of-balance, and severe, destructive, vibration.

Here's how it's done:

Pellerin-Milnor Corp., New Orleans, obtains the various speeds by using a separate motor for each different speed.



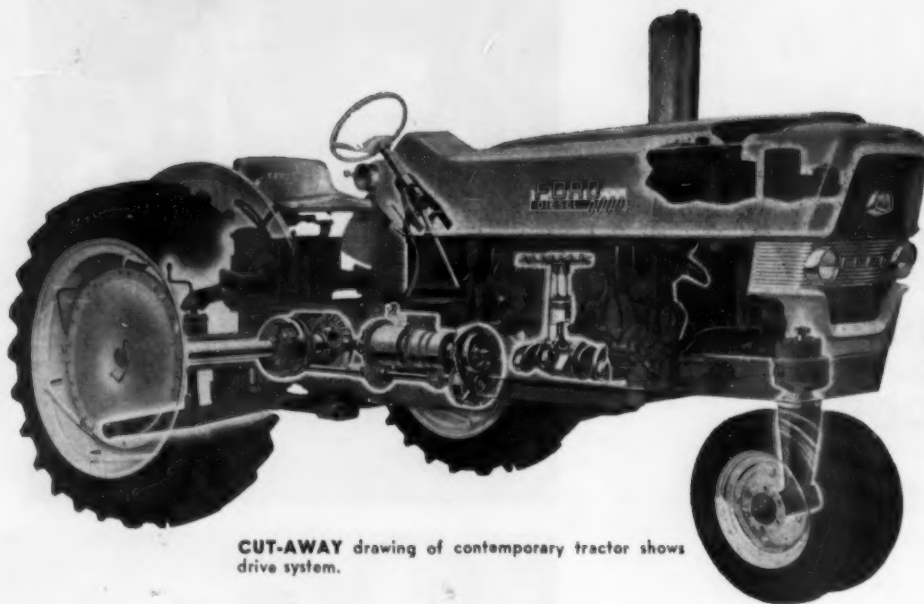
EASE OF DRIVE MAINTENANCE is typified by the machine's hinged motor mount. All components, such as the V-belts, are easily adjusted and replaced. The hinged motor has been tipped back to reveal the main drive shaft (top). Top view of a Milnor-300, showing the four single-speed drive motors (bottom). This machine can wash a 375 lb. load, unattended. Its largest motor is 7½ hp.

The low-speed drive is transmitted through an air-operated (expanding tire type) clutch, and a helical gear drive. It is the only machine built with a washer-extractor using helical gears for the low-speed power transmission.

The high-speed drive is a multiple V-belt system. However, brake torque is not transmitted through the V-belts. The self-adjusting brake operates directly on the main driveshaft sheave.

The largest machine in the series does not use a helical gear drive. To provide the necessary high torque, gear drives become very large, cumbersome, and expensive. So the manufacturer switched to a multiple V-belt drive, utilizing the narrow section, 8V belts. ♦

Tractor emphasize



CUT-AWAY drawing of contemporary tractor shows drive system.

What are designers of tractor drives doing to keep abreast of developments? We put this question to various tractor manufacturers. This article describes contemporary designs and tells what some engineers say about future tractors.

TO DEVELOP ITS RATED POWER, a tractor engine must operate within a narrow range of its rated speed. Placing a transmission between the engine and traction members does the job. The transmission reduces engine speed to obtain a practical ground speed.

Power transmitted by a rotating shaft equals the product of rpm and torque. Cutting the speed (at constant power) increases torque. To obtain the torque required at its wheels or tracks, reduce the speed between the engine and final drive of the tractor. Relation between horsepower, torque, and speed in rpm is

$$hp = \frac{2\pi NT}{33,000}$$

where hp = horsepower
 T = torque in lb ft
 N = speed in rpm

Efficiency, e , is

$$e = \frac{hp \text{ (wheels)}}{hp \text{ (engine)}}$$

or,

$$NT \text{ (engine)} \times e = NT \text{ (wheels)}$$

Therefore, torques and speeds are inversely proportional. Slow the wheels to increase wheel torque.

• **Types of transmissions**—These contemporary tractor transmissions employ hydraulics to help control power flow from engine to wheels: countershaft power shift, planetary power shift, and hydrostatic drive. The countershaft power shift and planetary power shift transmissions employ hydraulic clutches. Both of these transmissions have constant-mesh gears. Difference is that planetary transmissions have only one shaft. The countershaft employs multiple shafts.

The hydrostatic drive works on an entirely different principle. It has no transmission gears at all. A hydraulic system powered by the engine drives the rear wheels with hydraulic motors.

• **Countershaft power shift**—A constant-mesh gear train provides instant power shifting through its hydraulically operated clutches. It shifts to high or low range and to forward and reverse with the gears in constant mesh.

A torque converter is an integral and necessary part of this constant-mesh transmission because the converter absorbs shock. There is no mechanical drive through the converter. Oil transmits the power. The torque converter allows changing vehicle direction without stopping and shifting into power turns or counter-rotation while moving. J. I. Case Co. makes the transmission for its crawler tractors.

In the transmission, each clutch pairs with a clutch gear to form a clutch-gear assembly. Steel clutch plates having external splines are inserted into the clutch housing. These plates are assembled alternately with bronze friction disks that are splined to the hub of the clutch gear.

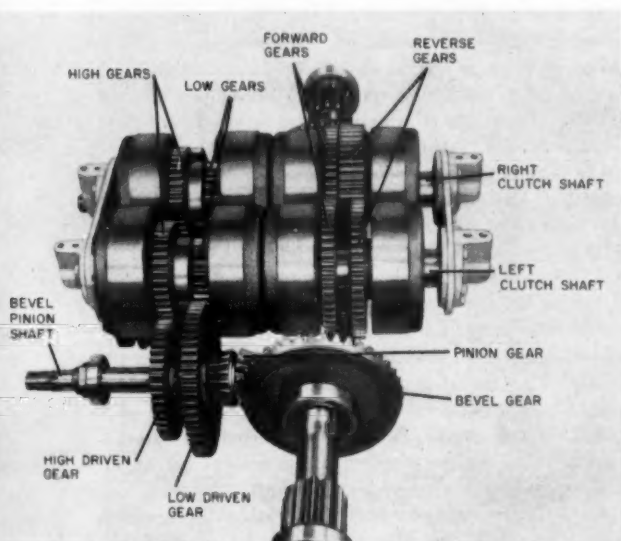
During clutch operation, oil under pressure pushes against a clutch piston. This forces the disks and plates together and binds the entire clutch-gear assembly as a single unit.

drive designs power and simple control

Clutch application is either engaged or disengaged. There is no way for it to slip. Hydraulic fluid passing through the clutch lubricates and cools the assembly. The clutches require no maintenance.

Clutches operate in pairs. When one clutch of a pair engages, the other disengages.

Releasing the hydraulic pressure returns the piston its original position. Fluid expels from the clutch, and the clutch disengages. The gear and the bronze friction disks are free to move independently of the



COUNTERSHAFT POWER SHIFT has constant-mesh gears and hydraulic clutches. Each clutch pairs with a clutch gear. Housing contains steel clutch plates and bronze friction disks assembled alternately. Hydraulic fluid under pressure forces the disks and plates together to transmit power.

What the engineers say . . .

. . . "a tractor's power train will become more important," according to J. K. Tomko, chief engineer at the Cleveland Plant of the Oliver Div. of White Motor Co. "The farmer wants a reliable power train made of good quality parts. Considerably closer manufacturing tolerances will be one means of making parts that last longer . . . Steam, as a power source, may be tried again. Atomic energy probably won't be used during our lifetime because of radiation."

. . . longer life with smaller components is the goal of another farm tractor manufacturer, according to its director of engineering research. However, he states, "Our farmer friends are not sold on the need for more exotic drives. Reliability and low cost still are most important to them."

. . . another agricultural equipment manufacturer says that the farmer is not particularly concerned about details of transmission design. He's interested in the ". . . transmission's ability to operate continuously with little or no down time."

. . . one chief engineer says that conventional manual-shift transmissions will still be used for many years. He gave ease of maintenance and repair as the main reasons.

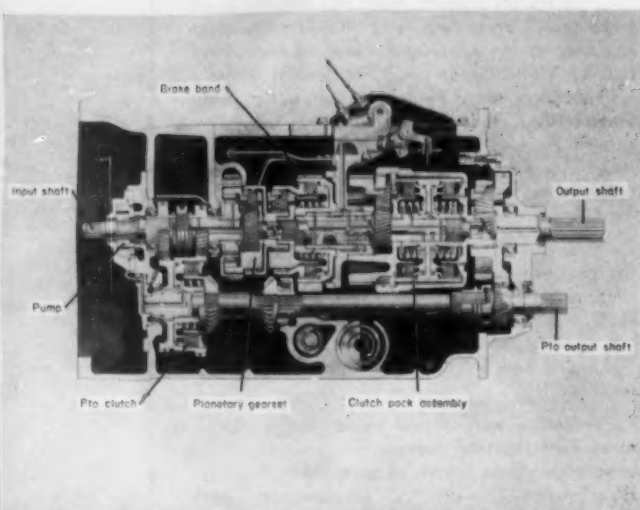
. . . L. E. Elfes, director of engineering at Massey-Ferguson Inc., Detroit, says, "The farmer is apparently satisfied that the transmissions available to him today are the best compromise between flexibility, cost, and reliability. This does not mean that he does not want more flexibility . . . he is not ready to sacrifice reliability, nor is he ready to pay a large premium, for a transmission which is more complicated . . . to achieve a nominal increase in performance and ease of operation."

. . . "the trend in tractor design toward increased power has a companion in the trend toward more exacting power control," says A. E. W. Johnson, vice president of engineering, International Harvester Co., Chicago. "The farmer of the future is going to demand the ultimate in both trends as he moves steadily from the art into the science of farming."

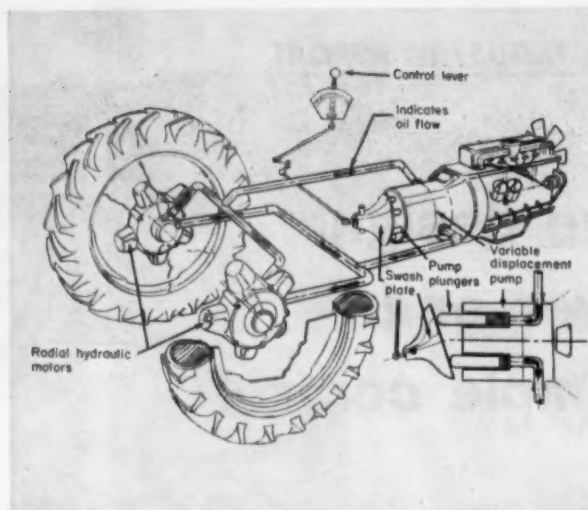
clutch housing and steel plates. When the gear is turning, clutch housing and shaft do not necessarily turn with it. When the shaft is turning, the housing turns but the gear is free to idle. The engaged clutch-gear assemblies transmit power while disengaged assemblies move but do not transmit any power.

All clutch gears ride the clutch shafts on ball bearings. All turn independently of their respective clutch housing and shafts as long as the clutches are disengaged. A clutch gear with its bronze friction disks may be revolving in one direction while its accompanying clutch, including steel clutch plates, is revolving the other way. Or, the two parts may be turning in the same direction at different speeds.

• **Planetary power shift**—Fluid power also helps drive a tractor with a 10-speed transmission. The



PLANETARY GEAR TRAIN provides power shift. Three internal clutches and bands control three planetary gear sets. A fourth planetary gear set gives constant gear reduction. Hydraulic pressure activates all clutches and bands.



HYDROSTATIC DRIVE SYSTEM employs a variable-displacement pump and two radial hydraulic motors. Engine supplies power for the pump which transmits the power to the motors. Each motor drives a wheel. Changing the swashplate angle changes the stroke of the pump plungers. This controls the power transmitted to the motors.

transmission requires no clutch pedal. A power shift enables the operator to change gears while the tractor is running. To shift gears, the operator moves a selector lever for the desired ratio. Ford Motor Co. makes this transmission.

Three internal hydraulic clutches and three bands controlling three planetary gear sets provide the power shift. A fourth planetary gear set gives constant gear reduction.

All gears are in mesh at all times. Application of various combinations of bands and clutches activates different sets of gears. Hydraulic pressure controls all clutches and bands. Bands first engage when the gear sets are at rest. Then the clutches engage to transmit power through the planetary gears. Most adjustments can be made from outside the tractor.

Ten forward and two reverse speeds provide a complete range for all types of work. Ratio change from one speed to another is kept at a minimum. Forward speeds range from 0.6 mph to over 18 mph. Reverse speeds are 1.8 mph to over 5 mph.

An automatic park feature of the transmission is a positive band lock-up of the rear wheels. It locks the wheels when the tractor engine is off, regardless of the position of the selector lever. The operator can engage it manually when the tractor is moving.

The tractor has a feathering (inching) pedal. It helps starting under heavy loads by moving the tractor slowly.

An independent power takeoff (PTO) enables the operator to engage or disengage PTO machines at will with the tractor in motion. In some transmissions, the power take-off has two gear ratios for standard speeds of 540 and 1000 rpm.

The transmission design provides for the addition of two side power takeoffs, one on each side of the

tractor. These takeoffs run at the same speeds as the rear PTO.

This transmission was developed for a 5-plow tractor that weighs more than five tons when fully loaded. It has 3-point lift linkage and twin-position steering wheel. Wet-disk hydraulic power brakes, power-adjustable rear wheels, and power steering are standard.

• **Hydrostatic drive**—One tractor has no transmission gears at all. It requires no gear-shift lever, no clutch, no brake pedals, and no rear axle. This hydrostatic system depends on fluid at high pressure to transmit power by acting on a moving piston. The entire complex of gears, shafts, and splines that were needed to transmit power from the engine to the driving wheels was eliminated. International Harvester Co. makes this transmission.

Oil is the driving medium. The oil is nearly incompressible. This makes the connection between the tractor engine and driving wheels practically as positive as if it were solid steel shafts and gears.

A pair of radial hydraulic motors and a variable-displacement pump are the main components of the hydrostatic drive. Each driving wheel has a hydraulic motor at its hub. A pump furnishes pressure to the system. This pump couples directly to the tractor engine. Piston action in the motors resembles that of a radial aircraft engine. Oil pressure, instead of expanding gases, moves the pistons. These pistons act on an eccentric which serves as a crankshaft.

Key to the system is the variable-displacement pump. The slightest plunger stroke is quickly converted by the motors to torque at the driving wheels. Changing the angle of a swashplate in the pump lengthens or shortens the stroke of nine plungers. This increases or decreases tractor speed. With the control

levers in neutral, the swashplate stops action of the plungers.

Oil in the system serves as a positive brake on the wheels. Because each driving wheel is turned by its own motor, it's possible to shut off pressure to a single wheel at a time. This brakes one wheel, diverts all pressure to the other for very short turns and better maneuverability.

The hydrostatic system at present cannot compete with conventional gear drives in fuel economy and cost of components.

● **New engine for hydrostatic drive**—A gas turbine engine may become the natural running mate for the hydrostatic transmission. International Harvester developed the turbine at its subsidiary, Solar Aircraft Co., San Diego. The turbine is 21 in. long, less than 13 in. in diameter, weighs 90 lbs, and develops 80 hp. It's a midget beside the 450-lb, 40-hp piston engine formerly paired with the hydrostatic drive.

The new turbine is similar to other gas turbines. It draws in air, compresses it, and mixes it with fuel in a combustion chamber. Hot gases produced from igni-

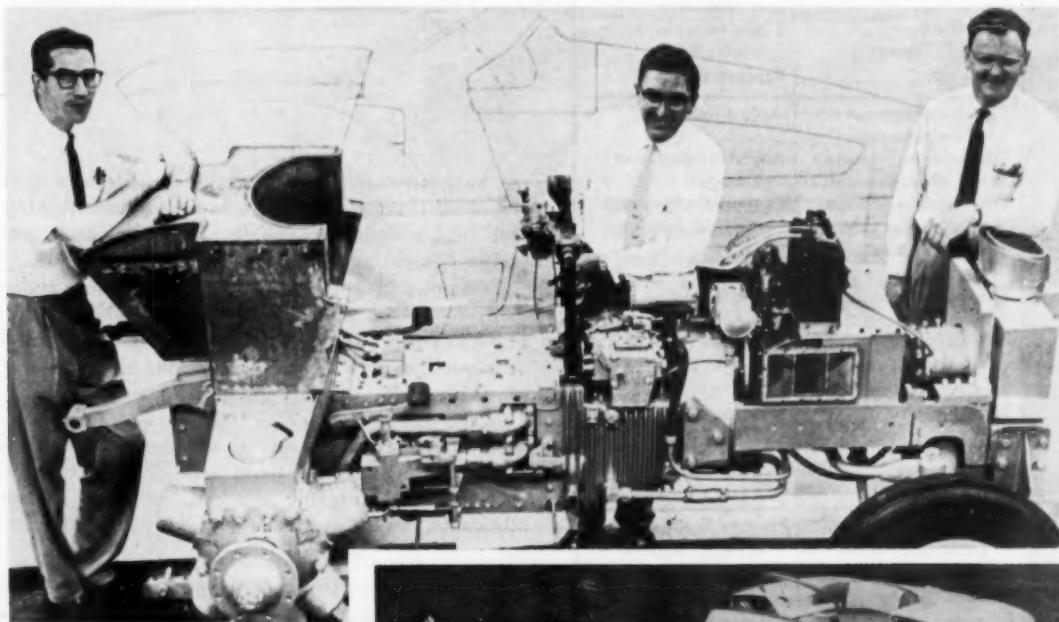
tion of the air-fuel mixture spin a turbine wheel. The turbine turns the output shaft directly, producing constant engine speed.

This simplicity of design has such advantages as:

1. Little vibration—a smoothly spinning turbine wheel and shaft replaces the reciprocating masses that generally make piston engines vibrate more than turbines.
2. Less maintenance
3. Little oil consumption—only a few bearings need lubrication.

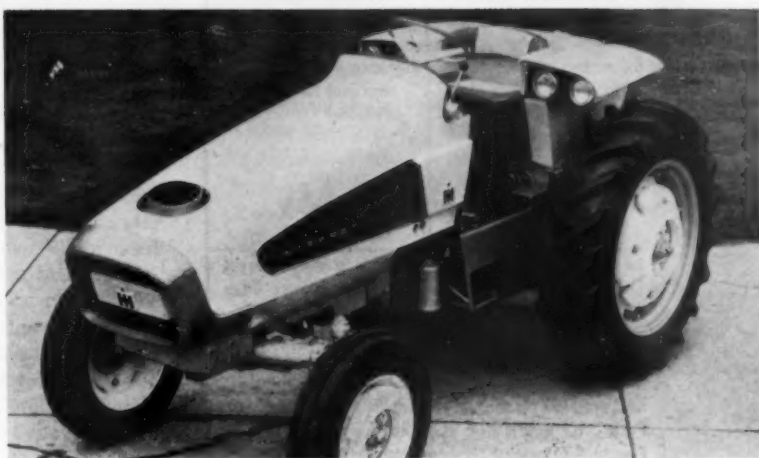
The turbine engine was small enough to warrant the designers working out a new exterior for the tractor. They used molded fiberglass as the chief material. New design has better visibility, better styling.

Despite recent progress with this turbine, it is not very economical of fuel. It also is noisy, except at full throttle, where it's not noisier than conventional engines. However, during idling, the turbine seems louder. This may be due to high frequency of pitch. The turbine will require further development before it can compete with conventional engines. ♦



TURBINE ENGINE permits rearrangement of tractor components. Note rear-mounted fuel tank, front exhaust, air intake on side.

NEW STYLING is one result of pairing the gas-turbine engine with the hydrostatic drive. Skin sections are molded fiberglass.



Checklist for troubleshooting transmissions

TROUBLE	PROBABLE CAUSE	REMEDY
Noisy transmission	Low oil level Improper oil Oil filter clogged Air leak in seals in oil pan Loose mounting bolts Backlash Damaged gear teeth Flaw in gear shaft Flywheel housing misaligned	Add oil to proper level Replace with proper oil Replace filter Replace seals and/or oil pan Tighten bolts to proper torque Replace gears Replace gears Replace shaft Realign
Excessive vibration	Loose mounting bolts Damaged gear teeth Faulty gearbox bearings	Tighten bolts Replace gears Replace bearings
Transmission running too hot	High oil level Low oil level Restricted oil cooler lines Backlash	Drain oil to proper level Add oil to proper level Clean or replace cooler lines Replace gears
Difficult to change gear ratios	Clutch linkage out of adjustment Transmission linkage out of adjustment Transmission linkage binding due to bent, worn, or broken parts Transmission remote-gear shift control tube binding due to misaligned steering gear housing Improper oil Damaged synchronizer assembly	Adjust linkage Adjust transmission linkage Replace faulty parts, readjust linkage Realign housing Replace with proper oil Replace assembly
Transmission will not stay in proper ratio	Transmission linkage parts worn, bent, broken, or out of adjustment Excessive endplay due to wear in the shift forks, sliding gear fork grooves, thrust washers, output shaft or counter-shaft bearings, or clutch pilot bushing	Replace faulty parts, readjust linkage Replace faulty parts, readjust for faulty endplay
Low oil pressure	Low oil level Oil lines restricted Leakage in cooler lines or fittings Faulty lube regulator valve Clogged oil filter Faulty oil pump Faulty thermostat	Add oil to proper level Clean or replace lines Tighten fittings or replace lines Replace valve Replace filter Replace pump Replace thermostat

Troubleshooting for manually transmissions

By NICHOLAS S. HODSKA, Design Engineer

Whether you are designing gear boxes on a machine tool, this

A TRANSMISSION SYSTEM usually consists of a gear box, clutches, couplings, brakes, universal joints, and all interconnecting shafts. Generally, each component is self-contained and replaceable.

Transmission components should operate satisfactorily for a minimum of 1200 hr before disassembly or replacement. They should not require adjustments or inspections for runout, backlash, and alignment during this period.

In the range of -65 F to 160 F, most transmissions should operate without special attention. Outside these limits, there might be permanent damage to some parts made of organic material, including certain lubricants. Severe overloads may damage components too.

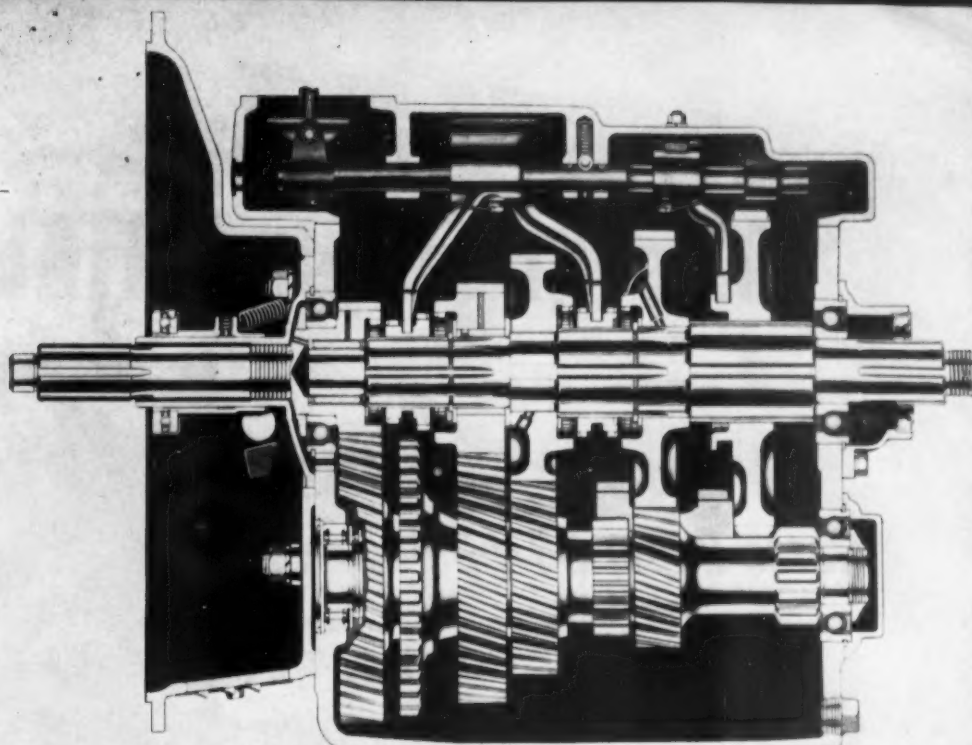
● **Gear ratings**—Proper gear ratings are essential to good service. Improper gear rating is a common cause for decrease in mechanical and rated power. Select ratings according to conditions of loading anticipated for the particular power plant (See "What's in the New AGMA Manual", POWER TRANSMISSION DESIGN, June, 1961, p. 33.). Using a transmission for purposes other than those intended in the design will make it inefficient or unreliable, or both.

● **Contaminants**—May get into a gearbox, even when it has been properly assembled and bolted. Key sources of contamination are inadequate parts preparation, backlash, heat generated from journal-bearing boxes, and foreign matter introduced during the running operation. Now and then, servicemen find flakes of preservative compounds, paint, or steel chips in a gearbox case.

guide operated

Stratford, Conn.

tractors or using
guide will help you.



Photo, courtesy White Motor Co.

High temperature and high speeds spread contaminants and foreign matter in a splash-lubricated gearbox. Some transmissions have a magnetic plug in the bottom of the gearbox. They attract some particles, keep them away from the meshing gear-teeth surfaces. Frequent inspection of this plug aids in establishing a proper overhaul period.

● **Transmission breakdown**—Major breakdown of a transmission need never occur if it is properly developed and serviced. In addition to the magnetic plug inspections, temperatures at significant points should be measured at frequent intervals.

Measuring oil pressure helps to show functioning of the lubrication system. Of course, it's a must to check oil level periodically. Proper transmission design and proper selection of lubricant will avoid faulty lubrication due to oil foaming.

The Checklist shows causes and remedies for common transmission troubles.

An over-noisy transmission can lead to complete breakdown in a short time, but some noise is normal. In many cases, simple preventive maintenance can save the expense of complete overhaul. This is true for such common troubles as transmission overheating, difficulty in changing gear ratios, and low oil pressure. All of these are included in the Checklist.

Dirty oil, although not troublesome in itself, is an indication that trouble can be expected. It may result from a clogged or faulty filter, excessive heat, or faulty operation of clutch or transmission components.

● **Gearing efficiency**—Efficiency of a transmission system depends not only upon the ratio and size of gears, but also on the sliding velocity. Efficiencies of power transmissions using spur and bevel gears are very high. Generally, there is a power loss of not more than $\frac{1}{2}$ percent for each set of spur gears in a train when a splash-lubricated bath is provided and the gear teeth are cut by modern machinery.

Difference between input and output horsepower turns into heat which must be dissipated. Heat dissipation of gears varies as a function of temperature. The danger point occurs in gears when their capacity to transmit power continuously is limited by the gearbox housing's ability to dissipate heat. Even in ordinary gearing, this limitation is below the required torque loads which the same gears can transmit in interrupted service or in operations where heat is not a decisive factor.

● **Lubrication requirements**—Moisture and corrosion play a major role in the degradation of many transmission systems. Thus, the preferred oil system must carry the oil through the gearbox case in a way that keeps bearing surfaces free from moisture and corrosion. Proper gaskets will provide a true hermetic seal.

It's desirable to have suitable identification near or on each part—drain plugs, connections, level cocks, vents, etc. This facilitates lubrication and other maintenance.

Normally, there is a removable oil screen at the discharge of the pressure pump in a pressure system.

Continued on page 46

The greatest TOTAL VALUE

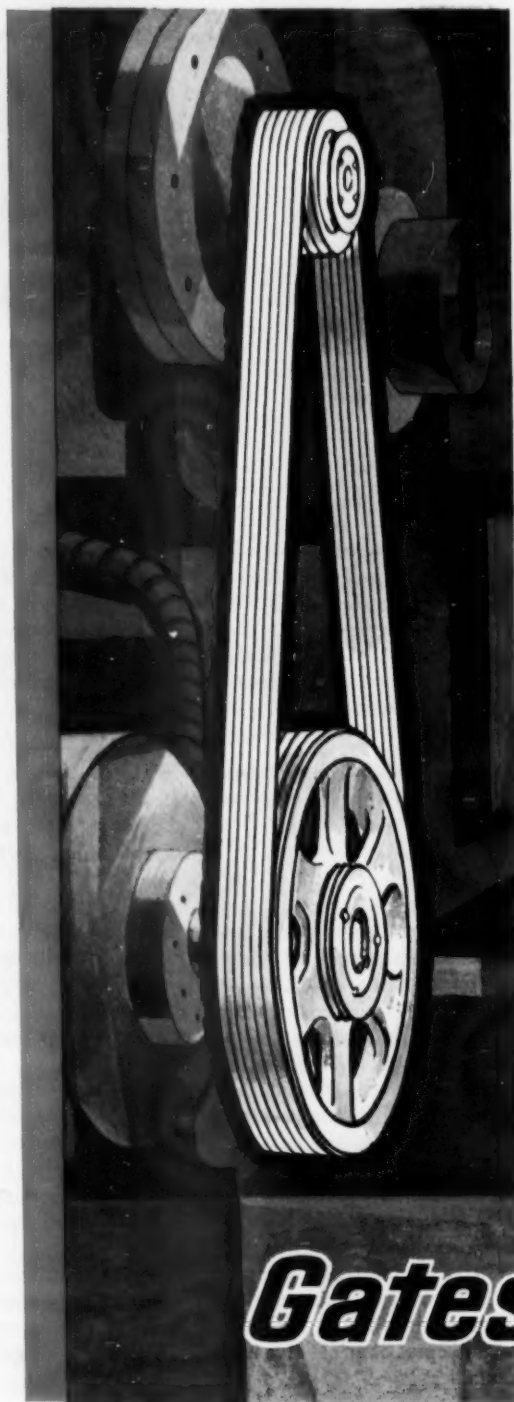
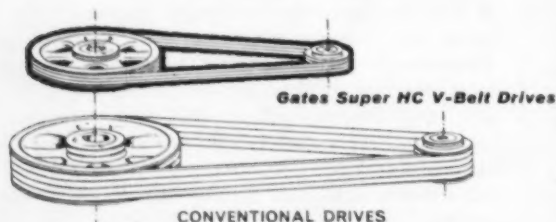
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The Gates Rubber Company, Denver, Colorado BP-53-A

Circle 49 on Reader Service Card

Quick and accurate indexing when clutch and brake interact

A LOW-COST MAKE-BEFORE-BREAK SYSTEM developed by W. H. Compton, of the Wood Compton Co., Cleveland, achieves high accuracy positioning without sacrificing feed speed. Energizing an electric brake before declutching the drive stops the load almost instantaneously.

In typical start-stop duty-cycle applications electric clutch and brake combinations operate without overlap. That is, the clutch is always de-energized before the brake is applied, and the brake is released before the clutch is engaged.

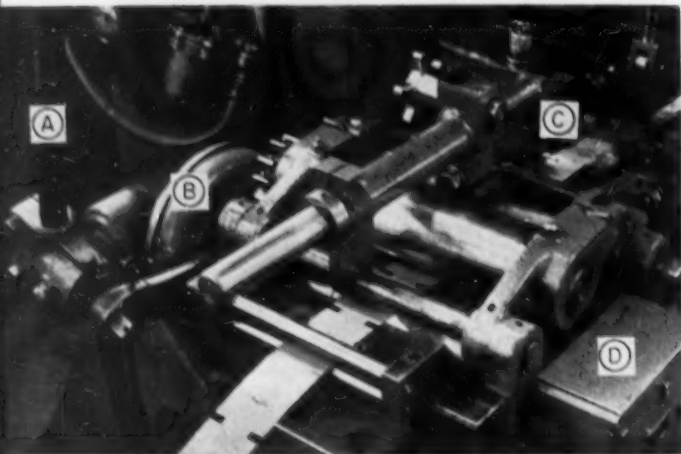
By reversing this order, it is possible to start and

stop a mechanism with far greater precision. The action is most easily explained in terms of the torque-time characteristics of the clutch and brake.

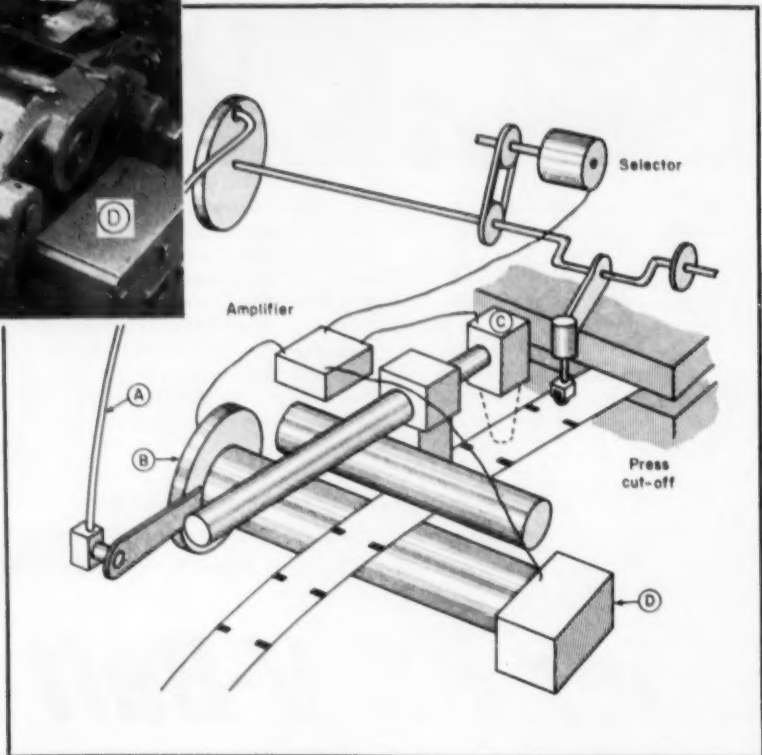
The clutch armature is generally attached to the drive shaft, and the magnet to the driven shaft. The brake magnet is attached to the stationary frame, and its armature to the load.

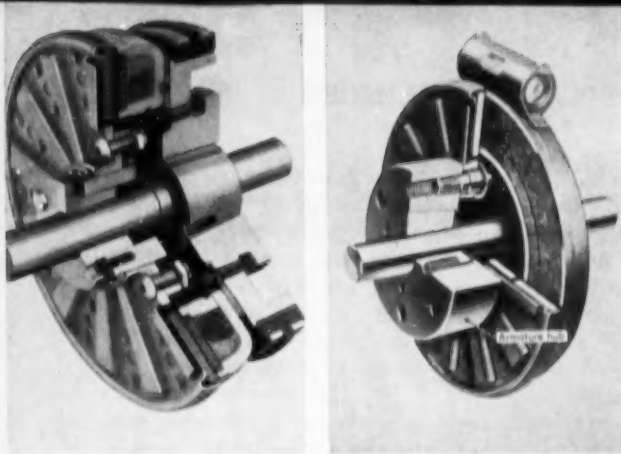
When the magnet is energized, magnetic flux builds up and pulls the armature towards the friction surface of the magnet. The resultant friction provides the torque to turn the load or stop it. When the magnet is de-energized, the armature is released as the magnetic flux decays.

As the magnet is energized, the flux builds up faster than the torque. But as the magnet is de-energized, the torque falls off faster than the flux. Capacitors in the control circuit will shorten the flux build-up and decay time, but the flux always leads the torque.



MODIFIED PRESS FEED DRIVE with photo-electric register control for indexing lithographed strip. Left to right are: (A) drive crank, (B) electric clutch, (C) photo-electric sensing unit and (D) shrouded electric brake. Sketch shows location of the feed drive in relation to the rest of the system.





CONSTRUCTION DETAILS of a typical electric clutch and electric brake.

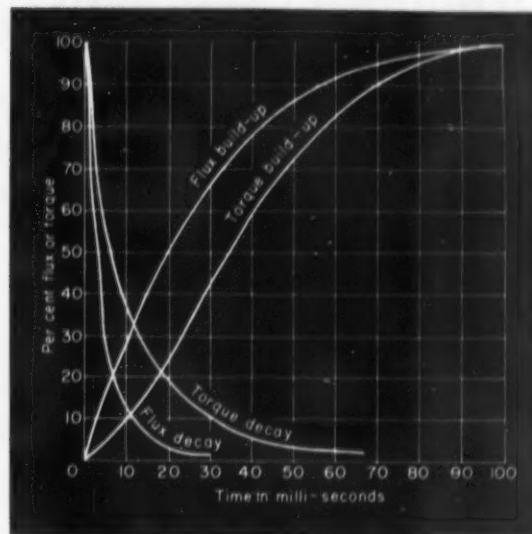
Courtesy Warner Electric Brake & Clutch Company

So there is always a short freewheeling time, during which the load is subject to the uncertain forces of friction. A good rule of thumb for estimating repetitive braking accuracy is ± 20 percent of the load travel during the stopping time. Obviously, anything that can be done to reduce this freewheeling time and the load travel will increase the accuracy of the stopping point.

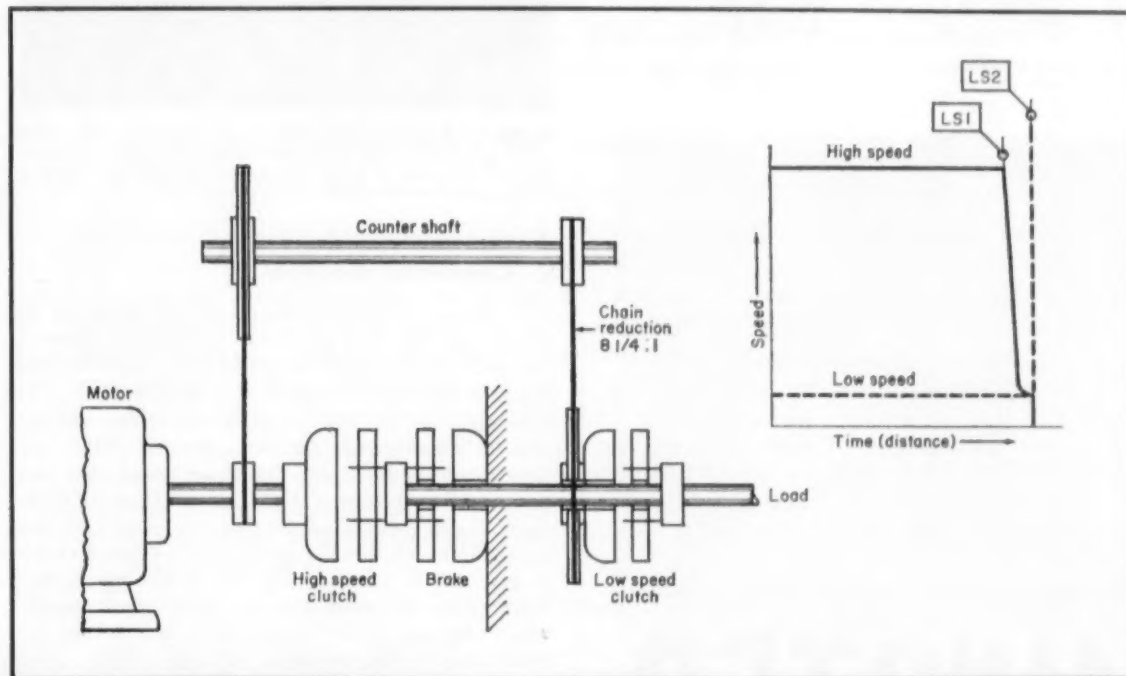
Here are two examples that used the "make-before-break" principle to advantage:

1. Press Feed Control

Feed motion is supplied to the main press drive through a crank, turning at 120 rpm. A cam switch on the press ram energizes a clutch at the beginning of each cycle to couple the feed rolls to the press crank. Almost at the end of each cycle, the cam switches on the brake and the photoelectric sending unit. A black mark



TORQUE-TIME CHARACTERISTICS of a typical clutch or brake. When the magnet is energized, the flux must build up to 90 per cent of final value before 80 per cent of the torque is available to the load. When the magnet is de-energized, the torque drops to 1 per cent in the time it takes the flux to decay to 10 per cent.

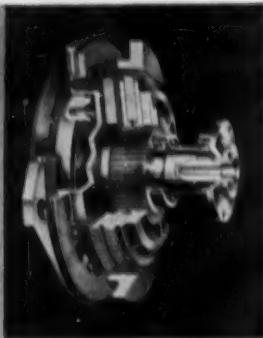


TWO-SPEED PRECISION BRAKING scheme for positioning tire tread conveyor. Slow speed clutch and brake are both energized when high-speed clutch is de-energized by the first

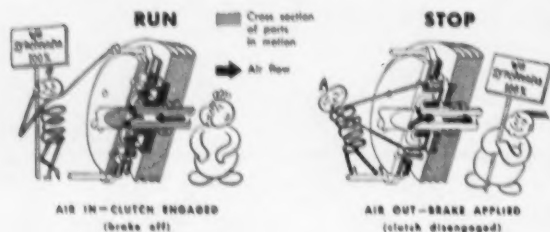
limit switch. The slow-speed clutch is then de-energized by the second limit switch and the load comes to a dead stop. LS1 and LS2 refer to the times of limit switch operation.

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Fast-Acting • Perfectly Synchronized



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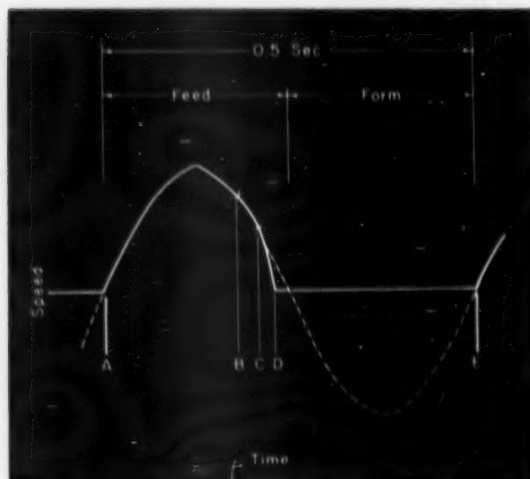
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QUICK AND ACCURATE INDEXING

on the lithographed strip triggers the photocell, which releases the clutch and allows the drive to be braked in the precise position for the forming operation.

Before the register system was installed, a mechanical clutching arrangement advanced the strip by a fixed amount each cycle. An operator adjusted the system periodically for cumulative errors that built up in the register. Only 25 pieces per minute were produced.

Now, the same press produces 120 pieces per minute, and no periodic adjustment is necessary. The registration marks have eliminated cumulative error, and individual errors are less than $\pm 1/32$ in. If it were necessary, this error could be reduced to $\pm 1/64$ in., with stopping intervals of $5/64$ in.



RAPID STOP START CYCLING is achieved on the sheet metal press with interacting clutch and brake. At point A, clutch engages. At point B, brake is engaged. At point C, clutch is disengaged. The press halts at D.

2. Conveyor Control

Production considerations called for speeds up to 200 ft. per min. in a tire tread process line. Material had to be cut to length within $1/32$ in., and the total stopping time had to be less than $1/2$ sec (Sketch p. 33).

In this case, the make-before-break system was applied to a 2-step stopping action, because of the very high speed of the tread. The tread passes over two limit switches in turn. The first de-energizes the high-speed clutch, and simultaneously energizes both the low-speed clutch and the brake. The low-speed clutch at first acts as a brake, and aids in slowing the tire down. Then the tread hits the second limit switch, which cuts out the low-speed clutch, and permits the brake alone to halt the load.

The tread moves $1/2$ -in. from the first limit switch to the second, which is just sufficient for the low-speed clutch to lock in. The load comes to rest between $1/8$ in. and $3/16$ in. past the second limit switch. ♦

New Model
FRACTIONAL HORSEPOWER
DYNAMATIC AJUSTO-SPEDE® DRIVE



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New in design but a veteran of proven dependability, the Eaton-Dynamatic Fractional HP Ajusto-Spede Drive offers a compact, low cost solution to adjustable speed control problems. Improvements include:

- Longer operating life • More uniform cooling
- Less noise and vibration • Lighter weight • Compact design

The Ajusto-Spede Drive offers advantages not found in other methods of control. It is low in cost and easily installed. It is an integral combination of AC constant speed induction motor, eddy-current couplings, and single tube, electronic control. Special control functions, such as acceleration, inching, threading, cascading of multiple units, follower operation, constant tension and clutch motor operation can be provided by remotely mounted electronic controls.

Ajusto-Spede Drives operate on standard 115/230 volt, single phase, 60 cycle or 220/440 volt, 3 phase, 60 cycle alternating current. No special power source is required. Available from the manufacturer or from your nearest Dynamatic Distributor in sizes of $\frac{1}{4}$, $\frac{1}{2}$, and $\frac{3}{4}$ HP at 1600 RPM and $\frac{1}{2}$, $\frac{3}{4}$, and 1 HP at 3200 RPM. Can be supplied with either of two types of electromagnetic friction brakes and integral speed reducer in a wide variety of gear ratios.

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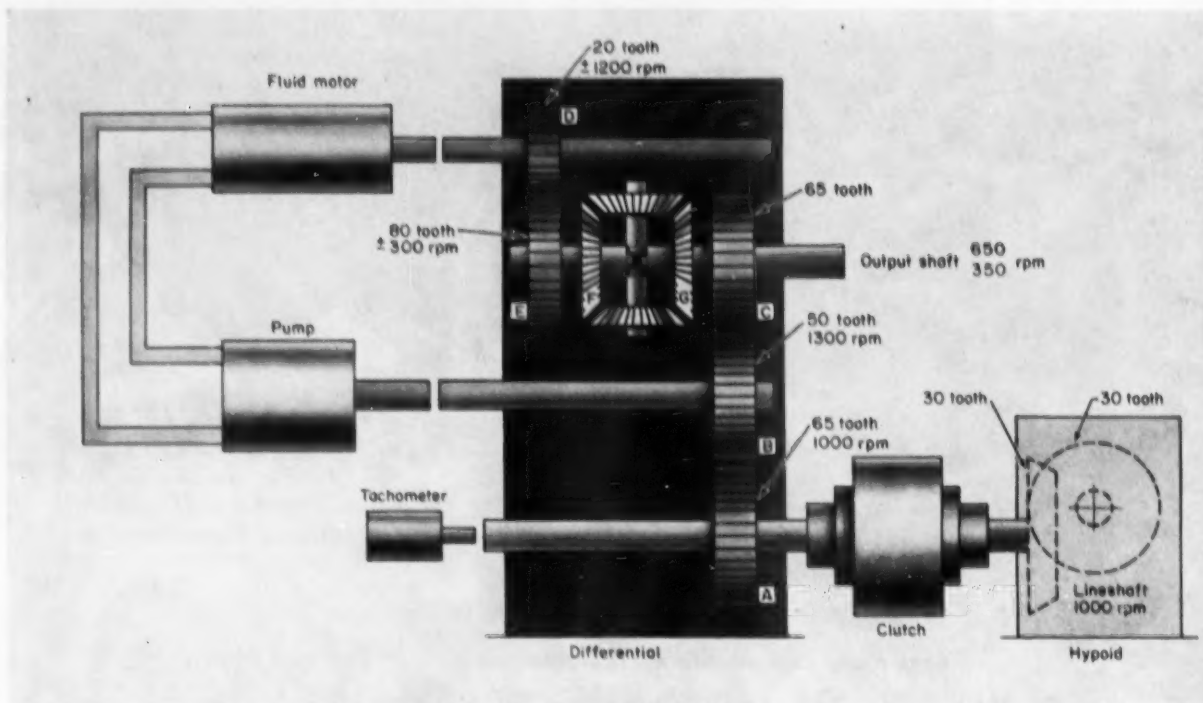
Circle 39 on Reader Service Card

Speed control for continuous

To make steel or paper in a continuous sheet requires a machine that has powered rollers controlling tension. What is the best drive system for regulating stand-to-stand speed?

This design combines the "hard" drive of direct gearing with the wide speed range of hydraulic control.

By CHARLES W. MODERSOHN, Staff Engineer



THIS DRIVE POWERS each stand on a mill making a product in continuous sheets.

MACHINERY THAT TURNS OUT A PRODUCT in a continuous sheet needs a drive that responds readily, and accurately controls the speed of each roll stand. The sheet is usually tensioned between stands.

In one solution to this drive problem, a group of differentials are driven from a common lineshaft. A prime mover powers the lineshaft. Each differential has a hydraulic section to control speed and torque.

• **What the drive does**—Curves show the speed relationship of the stands for a typical machine. The mill in this example is equipped with stands of 50, 100, 150, and 200 hp. Other similar drives, requiring less speed variation, have been built up to 800 hp. Overall mechanical efficiency is well above 90 percent at full load.

Each point on the curve corresponds to a dial setting on a control potentiometer. This setting relates output speed to lineshaft speed and may be repeated at any time.

• **Follow the gear train**—Speed relations are shown above. Lineshaft speed of 1000 rpm is assumed. This is then the speed of the input shaft to the differential. The 65/50 ratio of gears A-B will drive the variable displacement pump at 1300 rpm, and the 65/65 ratio of gears A-C will give a 1000 rpm input to the differential.

The pump is a reversible, variable displacement radial piston design. The motor is a fixed displacement unit. In this example, full pump displacement equals motor displacement. Allowing for some losses,

web drives

Beloit Iron Works

motor output is 1200 rpm. The 20/80 ratio of gears D-E results in a 300 rpm input to the differential. Varying pump displacement can change this input speed over a 0 to 300 rpm in both directions.

Bevel gears F-G are equal in pitch diameter, making the differential assembly a 2/1 speed divider. Thus the output shaft, which is integral with the cluster, will revolve at one-half the algebraic sum of the two inputs. For example, if the motor, and gear E are stationary, the output shaft will rotate at 500 rpm for 1000 rpm of the lineshaft. To this may be added or subtracted all or any part of $\frac{1}{2}$ (300), that is, 150 rpm by control of pump displacement and thereby motor speed.

Output speed becomes 500 rpm plus or minus 150 rpm, that is 500 rpm plus or minus 30 percent, or 650/350 rpm, a ratio of 1.857.

● **Regulated speed**—This drive has a sensing system which can relate the speed of each stand in the

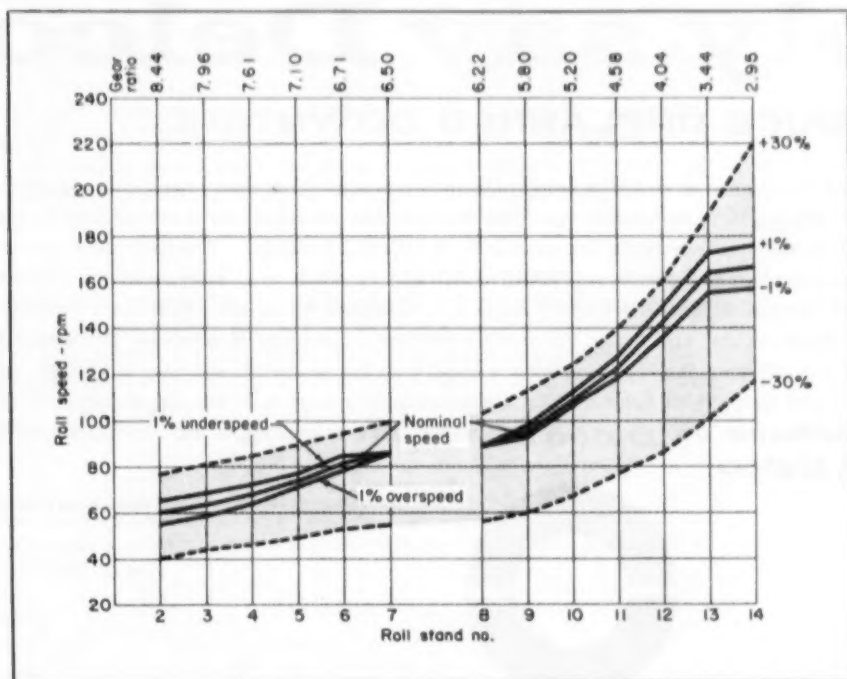
mill to give the desired tension in the sheet.

The master tachometer, shown coupled to the lineshaft in the schematic on p. 36, is a small, radial piston, variable displacement pump, very similar to the main pump except that the slide block is positioned by an electric motor through a ball screw and gear train. The motor is an element of an electrical servo-system.

Speed and direction of the motor shaft depend on the speed and displacement of the pump. The hydraulic pressure is a function of the torque load on the motor as imposed by the load through the differential. The pump is fitted with high-pressure relief valves to protect the mechanical and hydraulic components. These blow at 225 percent of full rated hydraulic load. A back pressure valve in the discharge line trips a pressure switch connected into the clutch control circuit to disconnect the overloaded stand from the lineshaft.

The entire system is one of relationship, and maintains output in ratio to the lineshaft input. Change the lineshaft speed and there is no unbalance. Motor speed will follow the lineshaft in the same proportion. The system accuracy is not affected by load. It is governing on speed, and will correct any tendency to lag or advance without regard to main system pressure. Transients of load will shift the leakage levels and require time for correction, but the response is rapid enough to avoid difficulty.

Regulation of the hydraulic system has been experimentally established at one-tenth of one percent. Since the hydraulic drive in the example is geared in at four to one, the overall regulation becomes correspondingly small. ♦



SPEED RELATIONSHIP of the roll stands. The differential supplies the range of speed plus or minus 30 percent. The drive is designed to give the nominal speed curve required by the product made on this mill.



DELCO NEW DEPARTURE SENTRI-SEAL

DELCO HYATT WOUND ROLLER

DELCO HYATT METRIC SERIES

DELCO NEW DEPARTURE LAND-RIDING SEAL AND TRASH SHIELD

simply say Delco

AND REDUCE UNPLANNED DOWNTIME...

Keep rolling equipment on the move; keep stationary units and tools in operation by making necessary bearings replacements with Delco New Departure Ball and Delco Hyatt Roller Bearings. They have become the standards of the industry because of their reliability and long life under the most severe service conditions. ■ **METRIC SERIES** . . . Precision roller bearings with built-in extra capacity for transmissions and gear boxes. **WOUND ROLLER** . . . Made in all sizes, operates with inner race or directly on shafting. **LAND-RIDING SEAL AND TRASH SHIELD** . . . Excellent for severe contaminant conditions, moist or dry. **SENTRI-SEAL** . . . Most popular seal today. For every contaminant condition. ■ Whatever the reason for equipment being out of service and in the shop, the important thing is to get it on the job quickly and keep it working. Your Authorized Delco New Departure and Delco Hyatt Bearings Distributor can help you do it. These top quality, precision **Delco New Departure** and **Delco Hyatt Bearings** are nearby, distributed nationally through **United Delco**



UNITED MOTORS SERVICE, Division of General Motors Corporation

Circle 107 on Reader Service Card

BEARING SECTION

HAROLD DELANGER
bearings editor

Bearing Business

The Kaydon Engineering Corp.—is investing more than \$1 million in a plant improvement program this year at Muskegon, which includes a 15,000 sq-ft plant addition. A massive rearranging of departments will improve work flow, similar operations will be centralized, and new machines and ultra-precision gaging equipment will be added.

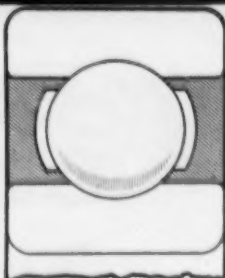
The Timken Roller Bearing Co.—put an office on wheels by converting a Metro Mite panel truck. The travelling office is used for making out billing, and checking steel billets or tubing from the company's Gambrinus plant to the Wooster plant, 30 miles away. The system allows the company to load freight cars from any point along a railroad track and have the papers on hand. No need to build temporary offices.

Power Instruments Inc.—have developed a low range, direct reading torque measuring meter that is sensitive enough to record the weight of a fly. The instrument (Torquemeter 781), offers a low cost method of measuring the relative torques of ball bearings synchros, hairsprings etc. The weight of a well grown fly turned out to be 45 milligrams.

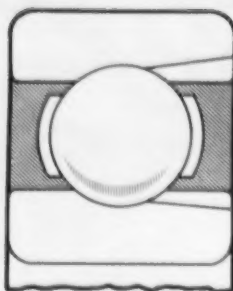
The United States Graphite Co.—appointed John Klonowski sales and application engineer to service companies in Connecticut and parts of New York state.

Scully-Jones & Co., Industrial Products Div.—appointed H. F. Wood Co., Pittsburgh, as representative for its new line of Tychoway recirculating roller bearings and Super Cision recirculating ball screws.

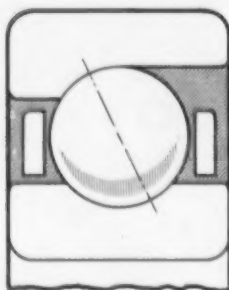




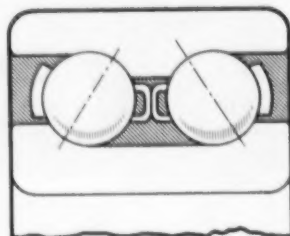
SINGLE ROW radial ball bearing



SINGLE ROW loading groove ball bearing



SINGLE ROW angular contact ball bearing



DOUBLE ROW ball bearing of the rigidly-aligned type.

Which bearing was that?

What to do, and what not to do, to identify a bearing after failure

By **R. M. MANSFIELD**, Vice President,
Tek Bearing Co., Inc., Stratford, Conn.

THE STANDARD EXTERNAL DIMENSIONS of bearings enables bearings from different manufacturers to be used as equivalents. Lamentably, it also permits maintenance personnel to wrongly substitute bearings of completely different internal construction and operating characteristics. Just because a replacement bearing exactly fits the space, does not mean it's the proper bearing.

Once install the wrong substitute and throw away the original, and there is little at all to go on. This can lead to continual bearing failure and replacement, and poor machine performance.

• **Most bearings are stamped . . .** with the name of the manufacturer and an identification number. The usual place is the face of the inner ring, the face of the outer ring, or both. Ball bearings with integral shields or seals, have the bearing identification stamped or molded on the seal or shield member.

• **But take care with special bearings . . .** This stamped identification is sufficient ordering data for normal applications. However, special bearings come

in many variations to meet specific conditions. Notable variations are:

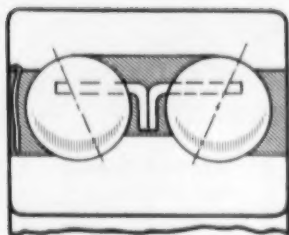
- special internal clearance
- precision grade
- special cage material and design
- nonstandard lubricant in sealed bearings
- special quietness specifications

Usually, special features are identified on the bearing by etched, burnished, or electric pencil markings. Now and then, they are not. Examine failed bearings for special markings. Carefully note the markings and where they are, and specify them when ordering the replacement.

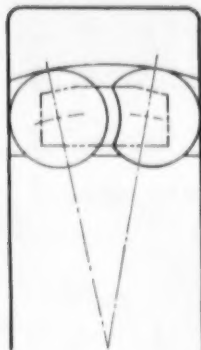
Interchangeability of maker's types

Obviously, no bearing distributor could stock the several hundred thousand sizes and variations of bearings made.

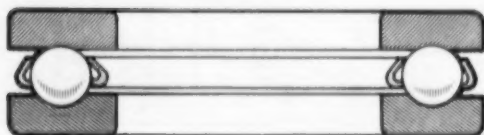
The Anti-Friction Bearing Manufacturers Association (AFBMA), by standardizing, has succeeded in



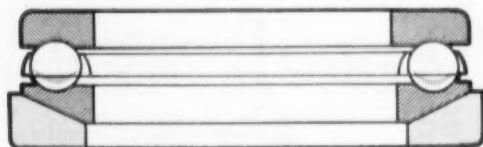
DOUBLE ROW ball bearing—
non-rigid type



SELF-ALIGNING dou-
ble row ball bearing.



BALL THRUST bearing



SELF-ALIGNING ball thrust bearing

reducing variations in size and tolerances. Standardization enables products of many manufacturers to be interchangeable. A bearing distributor will often substitute the equivalent bearing of a different manufacturer for the original bearing to be replaced. The bearing user must recognize that bearing distribution is complicated and must have confidence in reputable bearing specialists' ability to furnish the proper equivalents.

Removing failed bearings

The sort of failure influences the method of removal.

● **A seized bearing** . . . sometimes welds itself to the shaft. Then you have to cut or burn the bearing off the shaft. But first, record the manufacturers' name and the bearing number. Careful cutting or burning can reduce the amount of shaft refinishing required before installing a new bearing, and is well worth the effort.

● **Removal by arbor press or wheel puller** . . . is preferred and penetrating oil or ether between the press fitted members will help. You may have to heat the inner ring during the pulling. If you remove a bearing with a hammer and drift, don't damage the bearing ring markings.

Record the position of the bearing ring shoulders with respect to the shaft location. This can be done

CHECKLIST FOR BEARING IDENTIFICATION

Some failures obliterate bearing identification numbers and even the name of the manufacturer. Where identification must be made by plant maintenance personnel, identification is simplified by the following procedure:

1. Determine the type of rolling element in the bearing.
2. Identify the basic bearing type. In the case of cylindrical roller bearings, the number of lips on both inner and outer rings should be noted.
3. Note such features as shields, seals, snap rings, flanged od, spherical od, etc.
4. Note cage material and type.
5. Measure bearing bore, od, and the width of inner and outer rings. In the case of drawn cup needle bearings, the shaft seat diameter and the housing bore diameter should be measured rather than the bearing bore and od. Most anti-friction bearings are made to nominal metric dimensions—specify the exact dimensions measured. Do not approximate dimensions to the nearest fraction of an inch.
6. State any unusual conditions of operation that might warrant variations from standard bearings.

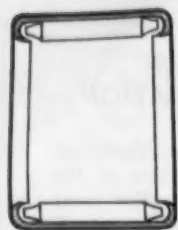
This information will normally allow your supplier to furnish a replacement.

during or immediately after removal. Replacement bearings must be mounted in this same position. Single row tapered roller bearings, angular contact ball bearings, and some types of cylindrical roller bearings have a heavier and a lighter ring. The heavy sides of their ring support applied thrust loads. Reversing the shoulder location of these bearings can completely destroy their effectiveness. Location of integral seals and shields must also be noted and replacement bearings mounted with this same location.

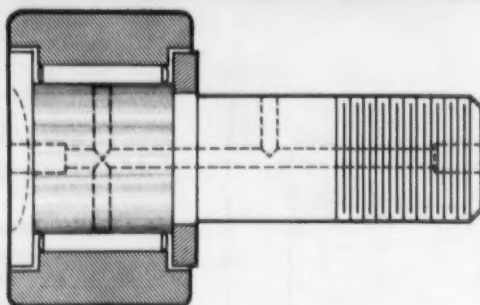
● **Duplex ball bearings** . . . usually consist of two or more angular contact bearings mounted abutting each other. They warrant special attention. Order and replace as matched sets—not as single bearings. Positions of the bearing ring shoulders relative to mating bearings as well as the shaft shoulder must be recorded.

Clean and inspect the bearing seat surfaces on shaft and housing after bearing removal. If the surfaces have worn, measure the diameters accurately, and correct them if they are not within the limits recommended in the bearing manufacturer's catalog. Bearing mounting fits are very important to bearing performance. Installing new bearings on worn or damaged seats is a false economy.

● **Lubrication holes** . . . channels, and fittings should be clear and clean. If the housing has external seals, they should be replaced. Commercial seals are inexpensive and readily available. Most bearings fail



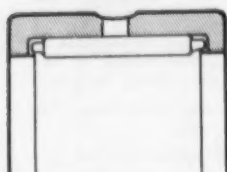
DRAWN CUP needle bearing



CYLINDRICAL roller bearing (cam follower)



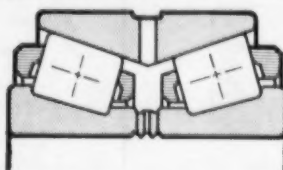
NEEDLE THRUST type bearing



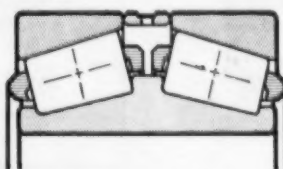
NEEDLE ROLLER bearing



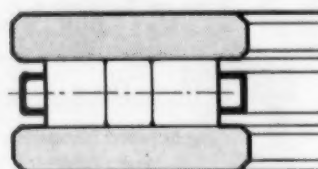
SINGLE ROW tapered roller bearing



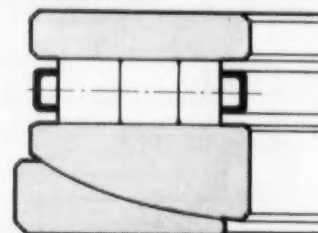
DOUBLE ROW tapered roller bearing-
Type TDO



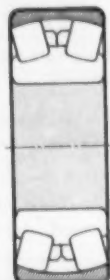
DOUBLE ROW tapered roller bearing-
Type TDI



CYLINDRICAL roller thrust bearing



SELF ALIGNING cylindrical roller thrust bearing



DOUBLE ROW spherical roller bearing

because of dirt or because the lubricant leaks away. New seals are additional insurance against failure of the replacement bearing from these causes.

Be sure the new bearing is right

Reduce downtime by having the replacement bearings at hand before taking down the machine. The bearing distributor can often furnish new bearings if given the make and model number of the equipment, and the location of the bearing that has failed. For custom machinery look in the parts manual or call the manufacturer of the machine for help. And when bearings are replaced, note the specifications in the maintenance record of the machine. If critical machinery uses nonstandard bearings, either stock spares at the plant, or arrange with a local bearing distributor to stock them.

Antifriction bearings usually fail with little warning. Furthermore, the machine must be dismantled to discover which bearing failed. This is a good time to examine all the bearings. After they are removed and their positions recorded, inspect them. Thoroughly clean bearings that do not have integral seals or shields. Use a good solvent and then examine them. The raceways should be examined for scratches or spalling if construction permits. Most sealed and

shielded bearings cannot be cleaned readily. Reject them if they are rough or excessively loose.

Bearings to be replaced should be examined for ring markings. Note the name of the bearing manufacturer. It may be a name or just the initials of the manufacturer. Next note the bearing number. This is usually a multidigit number or combination of letters and numbers.

● **Separable bearings** . . . many tapered roller bearings, cylindrical roller bearings, needle roller bearings, and journal roller bearings come apart. Each component has a separate identification number, and it must be given in the bearing specification. Usually it's best to replace all components of a separable bearing.

Most other bearings are nonseparable and have only one identification number. It is usually stamped on the face of the inner ring. However, when a second number is found on the outer ring, give both numbers in ordering, and tell the ring on which each number is found.

● **Sealed and shielded ball bearings** . . . The full identification number is on the shield or seal numbers. These bearings often have an identification on

Continued on page 44

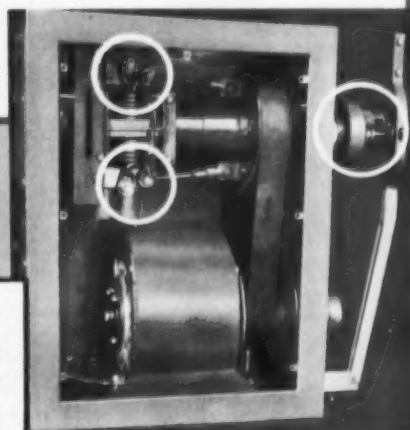
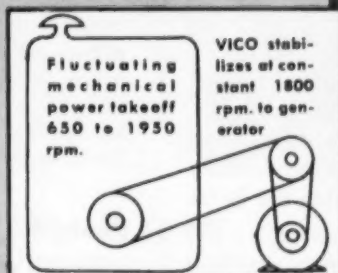


ORANGE **SEALED** *Cage Type* NEEDLE BEARINGS

--simplify design
--reduce bearing space
--save production costs
for
Allmand VICO Generators

THE VICO is an ingenious generator and drive which is attached to any fluctuating mechanical power source on cranes, shovels, trucks, drill engines, etc., and converts it to electrical power with constant voltage and frequency, up to 5 KVA. Auxiliary gasoline engines for electric power are eliminated.

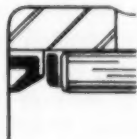
Ten Orange sealed cage type needle bearings are used—four double-seal bearings on each of the two governor arms and two single-seal bearings in the friction clutch. Allmand Brothers report these advantages: economy of design; bearing of small section to meet space requirements; and elimination of complex lubricating grooves in the clutch, by using single-seal bearings.



VICO Generators are manufactured by Allmand Brothers Manufacturing Co., Holdrege, Nebraska.

EFFECTIVE SEAL DESIGN keeps dirt out--lubricant in

Built-in Neoprene seals provide positive exclusion of foreign matter—retain lubricant—and will relieve pressure, preventing displacement of seals when bearing is overlubricated.

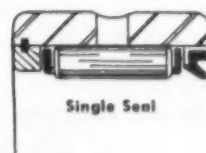


- Longer rollers for greater capacity
- TWO bearing lengths for flexibility
- Single or double seals to suit needs

Only Orange construction provides effective sealing without reducing roller length or load carrying capacity. Only Orange provides two bearing lengths for each shaft diameter, with full length rollers in proper proportion to race for maximum load-carrying capacity. Orange cage design guides rollers to prevent skewing and provides exceptional lubricant capacity.



Double Seal



Single Seal

Orange Cage Type Needle Bearings are stocked in popular sizes from 1/2" to 2" shaft diameters. Other sizes available as volume requirements are established.

WRITE FOR ENGINEERING MANUAL M-59

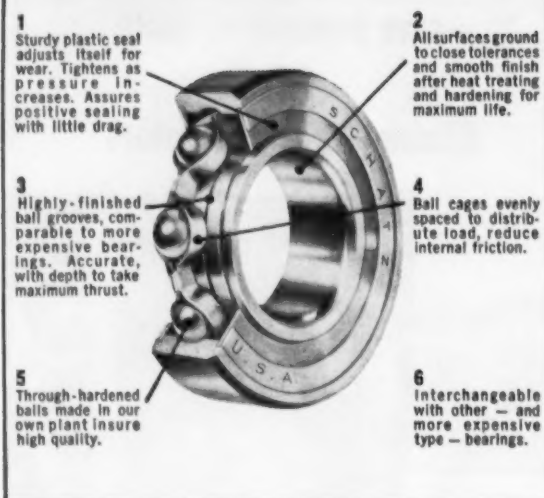
ORANGE ROLLER BEARINGS

ORANGE ROLLER BEARING CO., Inc.
552 Main Street, Orange, N. J.

Needle Bearings — Staggered Roller Bearings
Journal Roller Bearings — Thrust Roller Bearings
Cam Followers



How do the Ball Bearings you use measure up at these 6 important check points?



These 6 check points of Schatz "Functional Precision" bearing performance have proved out — and saved thousands of dollars—for many of the best known manufacturers of power lawn mowers, home laundries, home workshop equipment, farm machinery and others. They can do the same for your product, because

Schatz "Functional Precision" ball bearings provide all the precision you require—and need to pay for—under certain ratios of loads, speeds and life expectancy.

Their solid one-piece inner and outer races are machined from high quality steel. They are available in open type, single or double shielded; single or double sealed; with one shield and one seal. All double shielded and double sealed types are prelubricated. Bearings with snap rings, set screws, extended inner rings or special dimensions and tolerances may be had on special order.

Let us show you how these cost-saving bearings fit your production program. Write for Catalog 12.

The Schatz Manufacturing Company, 7640 Fairview Ave., Poughkeepsie, N. Y.

See our ad in SWEET'S



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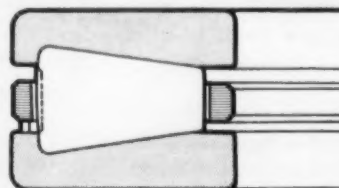
WHICH BEARING WAS THAT?

the inner ring as well, but it need not be used in ordering.

● **Journal roller bearings** . . . inner ring, outer ring, and roller assembly have separate identifications. Inner and outer rings are stamped on the ring faces, but roller assemblies are not always marked. The number stamped on the end ring must be accompanied by the roller assembly length. Some roller assemblies have no identification markings. Specify them by roller diameter, length of the assembly and diameter of the surface on which they roll.



SPHERICAL roller thrust bearing



TAPERED roller thrust bearing

● **Special bearing features** . . . indicated by etched, burnished or electric pencil markings. These are very important, and must be noted in ordering the bearing. All bearing markings have a purpose. Never be afraid of giving too many facts.

Features for unusual applications

Special bearing features, tolerances, and internal clearances are specified to meet unusual conditions. It is not easy to spot them, and it helps to be aware of jobs that might call for specials. In other words, you'll see more if you know what to look for.

● **Things to look for** . . . High speeds often require special cage materials and cage designs to reduce sliding friction between the rolling elements and the cage. Phenolic and nonferrous cage materials are common in high speed operation. Examine cages and note their material in ordering. At high speeds, slight eccentricities of the bearing can create imbalance and severe dynamic loads. Higher-than-standard precision grades may be needed. Carefully examine rings for additional markings denoting precision grade.

Bearing internal clearance is quite critical at high speeds. Often, internal clearances that are looser-than-standard are specified to allow lubricant to flow and to prevent binding caused by unequal thermal expansion of inner and outer rings. Clearances other than standard are usually noted by special markings on the bearing rings. Sealed bearings for high speeds may

Continued on page 46

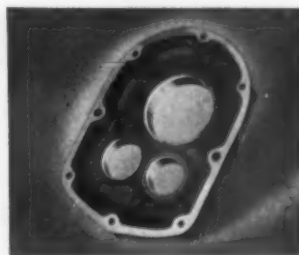
... the quality-engineered package

that simplifies speed reduction

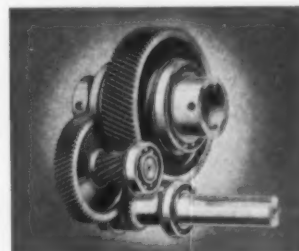


DODGE TORQUE-ARM, America's most widely used shaft mounted speed reducer, will save money for you. No foundation, no sliding motor base, no flexible coupling, no installation fuss. Developed and perfected by Dodge, this reducer has been so widely accepted in industry that it is now built and stocked in this unmatched range of sizes and models: capacities up to 170 hp; output speeds from 10 to 400 rpm; ratios of 5:1, 15:1, 25:1; speed ratios up to 175 to 1 with correct selection of speed reducer and V-belt drive. Built-in backstop available. Also positive overload release. Vertical models. Flange mounted models. Special application models... Go modern—go Torque-Arm! See your Dodge Distributor, or write us.

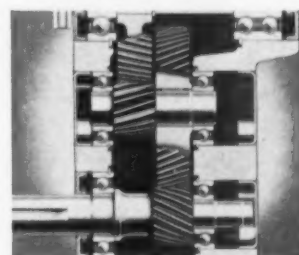
Dodge Manufacturing Corporation, 8200 Union St., Mishawaka, Ind.



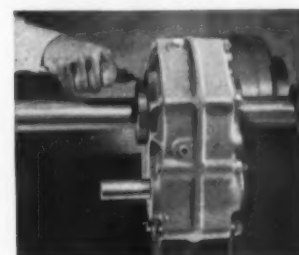
Rugged, semisteel housing holds bearing seats in line for entire life of unit. Laughs at loads. Corrosion resistant.



AGMA rated helical gears. Soft cores withstand shock; hardened surfaces defy wear. Teeth are crown shaved.



Gears are located between bearings and carry their loads without strain. Longer life, higher efficiency.



Unit slides completely onto shaft and locks on both sides of housing. This baby stays put—runs truer longer.

The Products with the Pluses...

DODGE

of Mishawaka, Ind.



CALL THE TRANSMISSIONEER, your local Dodge Distributor. Look under "Dodge Transmissioneer" in the white pages of your phone book. Factory trained by Dodge, he can give you valuable assistance.



flexible gear coupling you can buy!

Now you can transmit power in a wide range of speeds and capacities with the 14 ounce Nyflex® "Mite" nylon sleeve coupling. Use it in both the vertical and standard positions at speeds to 5000 rpm without lubrication. The "Mite" absorbs up to $\pm 3^\circ$ misalignment at these speeds yet the whole coupling is less than 3" in diameter.

The "Mite" is available now in $\frac{3}{8}$ " rough bore and 8 finish bore sizes from .500" to 1.125" through over 150 industrial distributors. Use the inquiry card or write direct to Sier-Bath for the name of your nearest distributor and complete performance and specification information on the "Mite".



SEND FOR YOUR DESIGN CATALOG TODAY!

Sier-Bath

GEAR AND PUMP CO., INC.

FLEXIBLE COUPLING DIVISION

9252 HUDSON BLVD., NORTH BERGEN, N. J.

Member A.G.M.A.
Founded 1905

Circle 93 on Reader Service Card

TROUBLE-SHOOTING GUIDE

continued from page 29

This screen filters out foreign material from the oil. In addition, a bypass of the screen provides continued flow if the screen clogs. Inspect this screen at frequent intervals. Remove and clean it regularly.

• **Leakage test**—There are many ways to test a gearbox for oil leaks. An effective one is a preproduction test performed on samples of the production item. The test determines whether or not production meets specifications.

Before testing any gearbox, remove all corrosion-resistant compound from the gearbox. Also, remove any corrosion-preventing oil or grease. Lubricate the gearbox at the beginning of operation. No oil need be added for 50 hr of continuous operation. Record gearbox speed in rpm every 15 min during all operations. Measure and record temperatures as near as possible to bearings every 15 min during these operations. Reject gearboxes that run too hot.

The gearbox should operate satisfactorily for a minimum of 5 min at increments of 500 rpm to normal rated speed. Bearing temperatures should stabilize at each speed. ♦

WHICH BEARING WAS THAT?

continued from page 44

require special seal fits or special seal constructions to avoid excess heat. Examine the seals of these bearings for special markings.

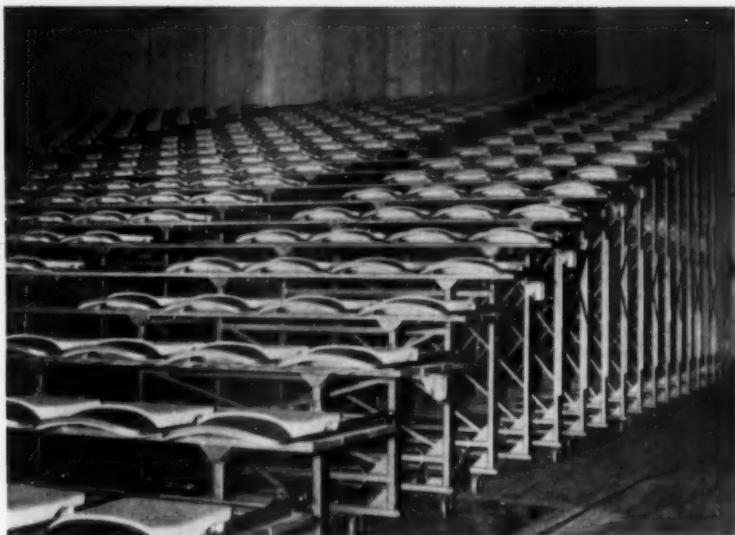
• **High operating temperatures** . . . (over 250 F) usually dictate special bearing features. These include: special ring materials or heat treatment, special cage materials, and looser-than-standard internal clearances. Sealed bearings for high temperature applications require special seal materials and must be prelubricated with a high temperature lubricant. Take exceptional care in identifying bearings for high temperature service. When in doubt, ask the maker of the machine.

Where there's danger of corrosion, stainless steel may be used. Stainless steel for bearings is AISI 440C. It is a magnetic material and may not be identified with a magnet. Most stainless steel bearings are identified by a prefix to the basic bearing number marked on the bearing rings. Sealed bearings for wet or corrosive conditions may have special seals and may be prelubricated with water resistant grease.

Machine tool spindles and the like require high running accuracy, demand precision grade bearings.

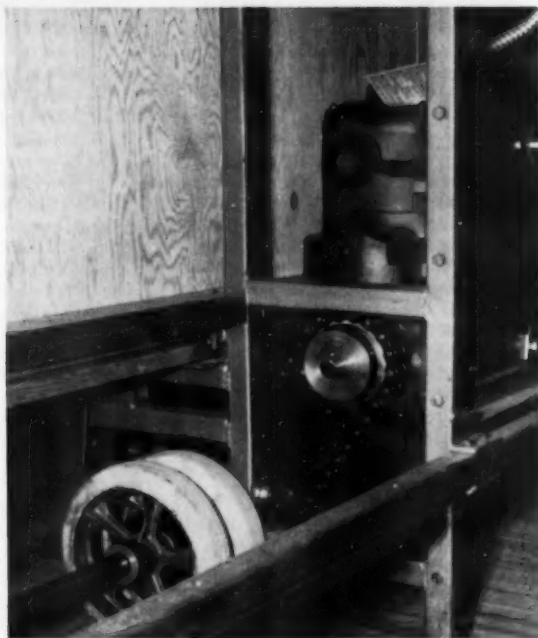
Hasty identification to get a machine back into service quickly is unsound. A little extra effort spent in identifying and specifying proper replacement bearings will pay dividends in performance and life. ♦

Gearmotor moves bleachers



GEARMOTORS move these bleachers into position for various sporting events. Photos courtesy Reliance Electric and Engineering Co.

ONE ¾-HP GEAR-MOTOR supplies power to move the rubber wheels on each bleacher section.



A GEARMOTOR WITH A foot-mounted arrangement moves sections of gym bleachers into position for different sporting events. The Berlin Chapman Co., Berlin, Wisc., makes the bleachers.

One ¾-hp right-angle gearmotor powers each bleacher section. Each section is 16 ft. wide, 24 ft. high, contains 20 rows, and weighs about

4 tons.

The gearmotor output shaft is under the worm. A chain connects the output-shaft sprocket to the bleacher drive-shaft sprocket. Four 10-in.-diameter rubber wheels are mounted on the bleacher drive shaft. These wheels move the sections at about 40 fpm with a gearmotor speed of 11.6 rpm.

GEARED to the FUTURE



SPUR GEARS AND PINIONS
3 to 24 diametral pitch, iron and steel.

BEVEL GEARS AND PINIONS

3 to 14 diametral pitch, iron and steel.



MITER GEARS
4 to 14 diametral pitch, iron and steel.

WORM GEARS AND WORMS

3 to 14 diametral pitch, hardened or bronze worm gears and steel worms, soft or hard.



BOND STOCK GEARS are engineered applicable to every requirement... Present and future. Engineered for greater **ECONOMY, STRENGTH, ACCURACY** and **UNIFORMITY**.

BOND Stock Gears are available for immediate delivery from our master stock or from coast-to-coast Distributors. Engineers, draftsmen, machine builders and users specify BOND for dependable quality.

Let our catalog work for you. Detailed engineering charts and diagrams save you time, making Gear specifying fast, easy and accurate. Write for your **FREE** copy today.

CHARLES BOND COMPANY

17 Arch St., Phila. 4, Pa.

Circle 16 on Reader Service Card

POWER TRANSMISSION DESIGN

FREE REFERENCE MATERIAL from this month's ads

Readers may obtain any of these reference materials by circling the numbers on the reader service cards.

OFFERED FOR THE FIRST TIME . . .

The services and reference materials listed here are being offered by advertisers to readers for the first time

3. ROTARY TRANSMISSION—Airborne Accessories Corp.—write for catalog IR-61 on the how the Roto-Mission works.

4. DIHEDRAL COUPLINGS—Ajax Flexible Coupling Co.'s catalog gives the details on a line that can take misalignment up to 7 degrees.

5. LUBRICANT COATING—Alpha-Molykote Corp. offer free sample in applicator bottle of Molykote M-88 bonded anti-sieze coating.

7. LIQUID METAL SEALANT—American Sealant Co.'s Loctite Sealant can simplify shaft assembly problems, end vibration loosening. Literature and free samples.

10. HINGED PLATEGRIP—Armstrong-Bray & Co.—Catalog tells you how to quickly extend or shorten heavy conveyor belts.

15. SHAFT MOTION INDICATOR—Bin-Dicator Co. will send Bulletin RG-21 on the Roto-Guard protective indicator.

16. STOCK GEARS—Charles Bond Co.—Catalog with detailed engineering charts makes gear specifying fast and accurate.

20. DRIVE TENSIONER—Brewer Machine & Gear Co.—Write for information on the Universal Drive Tensioner and stock bronzed bushed idlers.

25. CUSTOM GEARS—Cincinnati Gear Co. offer brochure on gears and gear boxes to exact specifications.

28. GEARMOTORS—Cone-Drive Gears—Details of hollow shaft speed reducer-motor which forms a complete transmission package.

34. SPROCKETS—Dayton Rogers Mfg. Co.'s catalog No. 2 has all the data on low cost Darco sprockets.

45. CHAIN AND SPROCKETS—Fort Worth Steel & Machinery Co. will send Catalog 320 on QD sprockets with tapered, split interchangeable bushings.

48. PLASTIC BEARINGS—Garlock Inc.—Engineering Catalog DU-458 tells how to apply DU dry bearings to appliances, autos, industrial machinery etc.

49. V-BELT DRIVES—Gates Rubber Co. feature the Super HC and other drives in comprehensive product and design catalogs.

59. AIR BRAKES—Horton Mfg. Co.—Air-Champ brakes with forced draft cooling are featured in this brochure.

39. ADJUSTABLE DRIVE—Eaton Dynamatic Div. describe their fractional hp Adjusto-Spede in an improved design.

69. MOTOR BASE—Manheim Mfg. & Belting Co.—Send for bulletin on the new Automatic motor base to cut down stress on belts and bearings.

75. CHAINS—Moline Malleable Iron Co.—Design Engineer's Handbook lists all types and sizes of chains and attachments, with many suggestions for application.

125. ULTRA SPEED BELTS—Russell Mfg. Co. offer a sample kit and brochures on ultra speed and endless belts.

62. ELECTRIC CLUTCHES AND BRAKES—The Carlyle Johnson Machine Co.—Solutions for clutch or brake problems in Bulletin No. 90.

71. TENSIONERS—Maurey Mfg. Corp.'s Catalog TR-1 gives all the facts on Hi-Q Tensioners for V-drives, flat belt, positive, and chain drives.

74. CLUTCH/BRAKE—Minster Machine Co.—Write for OEM Clutch Bulletin 16. Shows the advantages of the Minster combination clutch brake for original equipment needs.

79. CHAIN OILER—Oil-Rite Corp.—Bulletin covers many styles of electro and manual chain oilers.

80. NEEDLE BEARINGS—Orange Roller Bearing Co.—Bearings with double or single Neoprene seals are included in Engineering Manual M-59.

85. FRICTION MATERIALS—Raybestos-Manhattan offer R/M Bulletin No. 501 packed with clutch and other engineering info.

92. BALL BEARINGS—Schatz Mfg. Co. will show you how to fit cost saving precision bearings into your production program. Catalog 12.

93. FLEXIBLE GEAR COUPLING—Sier Bath Gear & Pump Co.—Design Catalog includes complete performance and specs on the 14-oz Mite nylon sleeve type.

94. MINIATURE CHAIN—Sierra Engineering Co.—Tables, specs, data and suggestions for calculating center-to-center distance.

97. REVERSING TRANSMISSIONS—Snow-Nabstedt Gear Corp.—

Write for technical data on 5 models, 8 and 28 hp.

99. ELECTRIC CLUTCHES—Stearns Electric Corp. include the new 540 in. lb. torque Model 5.5 in Clutch Data File 61C.

103. FLEXIBLE COUPLINGS—Thomas Flexible Coupling Co. tell you how to cure "couplingitis" in New Engineering Catalog 60.

112. CLUTCH-BRAKE DRIVE—Warner Electric Brake & Clutch Co. will send full details of the Electro-Pack drive.

113. DRIVE SHAFTS—H. S. Watson Co.—New 8-page Engineering Data Bulletin F-15a is yours for the asking.

119. TIMING BELTS—T. B. Woods Son's Co.'s Bulletin 21103 includes 5 charts for working out drive designs with minimum math.

120. DRIVE SYSTEMS—Worthington Corp.—Three how-to-figure-it design manual's, on Multi-V., Multi-Wedge, and Positive drives.

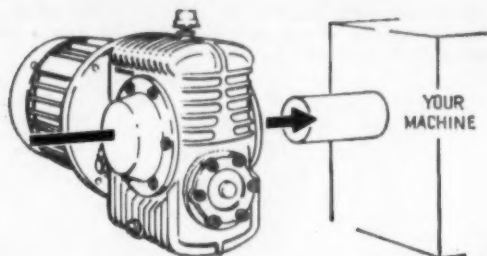
121. DRIVE CONTROLS—The Zero-Max Co.—Catalog includes details on stepless variable speed control.

124. KEYWAY BROACH KIT—The duMont Corp.—Catalog and price list includes info on time saving Minute Man kit.

126. ROD ENDS—Split Ballbearing Div., MPB, have a complete catalog on Alinabal rod ends and spherical bearings.

128. BEARING BRONZE—Bearium Metals Corp. offer the Berium Metal story, tells how this metal outperforms other materials.

CONE-DRIVE GEARMOTORS for "PLUG-IN" POWER



Hollow-Shaft Speed Reducer-Motor forms complete power transmission package . . .

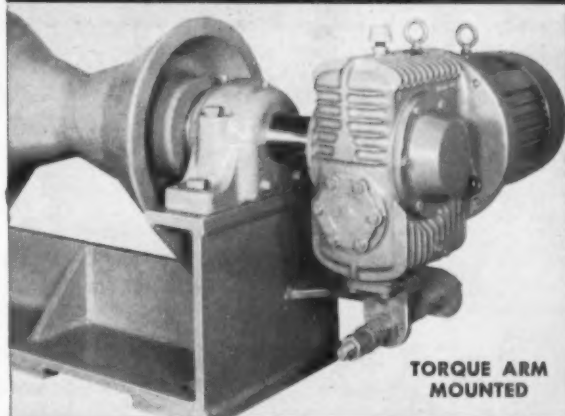
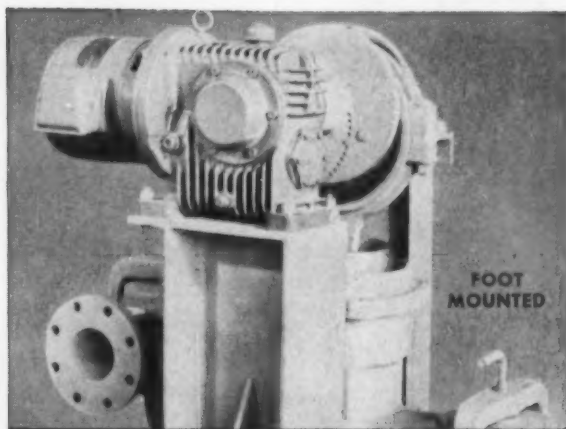
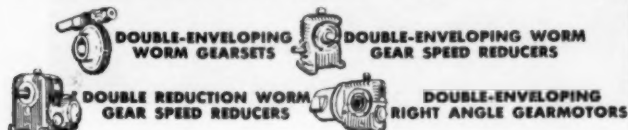
With the compact, right-angle Cone-Drive gearmotor the machine designer can make use of an integral drive package of nearly any required speed and horsepower. Twenty-seven standard output speeds from 7.3 to 525 RPM (with 1750 RPM motor) are available in models from $\frac{1}{4}$ to 40 horsepower. Gearmotors can be specified with hollow shaft for mounting in any position, ready to "plug-in". You can use this integrated power package to provide a simple, clean installation on your machine . . . no pulleys, belts, sheaves, bed plates, couplings, etc.

Electric motors are standard "D" flange type with slight shaft modification for driving helical primary reduction gears. Secondary reduction stage is a standard Cone-Drive double-enveloping worm gearset with maximum tooth engagement for greater load carrying capacity in smaller space.

Cone-Drive gearmotors are available for all AGMA service ratings. Call your Cone-Drive representative today or write for catalog #58 for complete specifications.

CONE-DRIVE GEARS DIVISION MICHIGAN TOOL COMPANY

7171 E. McNichols Road Detroit 12, Michigan Telephone: TWinbrook 1-3111



Circle 28 on Reader Service Card

Self-driven pulley immune to dust

A SELF-DRIVEN PULLEY does not clog when conveying dry fertilizer at the Davison Chemical Co., Baltimore. There is no power drive loss because the pulley is the motor frame. The pulley has completely sealed bearings, runs at 200 fpm. The power line is taken to the stationary sliprings. The whole pulley, including motor, spins at 1750 rpm. The distributor recommended the Bauer self-driven pulley.

The old conveyor system demanded constant cleaning and servicing. The motor clogged with dust no matter where it was mounted. The new system is highly efficient and needs little maintenance.



DESPITE THE FINE DUST in the atmosphere, this self-driven pulley has been in service, without trouble, for over a year. Courtesy M. F. Holland Co., Baltimore.

Carts service pinspotters



CARTS service 60 automatic pinspotters. Their controlled environment (always indoors) and specialized operation made the design very simple and economical.

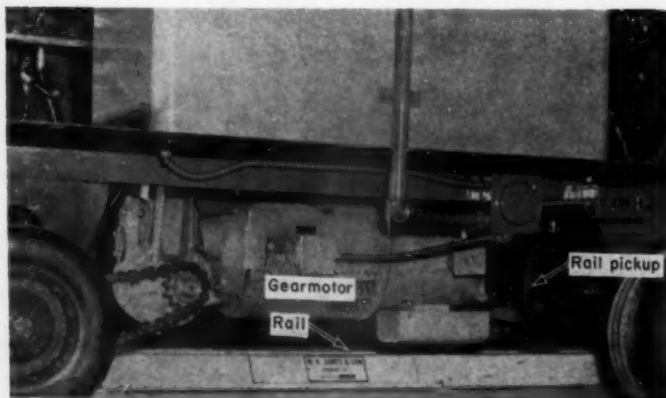
SERVICE CARTS keep 60 automatic pinspotters ready for action in a Buffalo bowling alley. Integrated gearmotor packages power the carts. Each cart carries a mechanic and tools. The carts reduce pin-spotter downtime by a half.

The combination fluid-drive gearmotor gets its current from a rail pickup on the floor. There are no overhead cables or trolleys. Reliance Electric Co., Cleveland, makes the gearmotor.

The motor is quick-reversing, 1 hp single-phase, averages 45 starts and stops per hour. Load brakes stop the cart fast and fail safe if power fails.

The fluid drive accelerates smoothly. Reduced starting current of the gearmotor prolongs the life of the contact shoes on the power pickup.

The cart serves as a workbench. A drum switch mounted above the tool box on the cart platform quickly reverses direction, so carts can move rapidly from one pinspotter to another. Carts by W. H. Jones and Son, Buffalo.



DRIVE SECTION of service cart. Even the carts themselves are designed for minimum maintenance.

Circle 91 on Reader Service Card

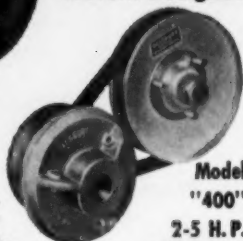
SALSBUry

AUTOMATIC CLUTCHES AND TRANSMISSIONS



**Centri-Dyne
Clutches**
6-100 H.P.

For gasoline engines, gas turbine engines, electric motors. Designed to rigid specifications; engineered and operation-tested to meet highest performance standards. Approved by leading manufacturers. Confidential engineering assistance without obligation.



Model
"400"

2-5 H.P.



Model
"600"

6-10 H.P.

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"Since 1936"

1161 E. Florence Ave., Los Angeles 1, Calif.

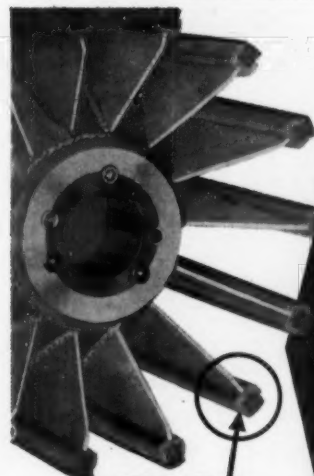
Circle 4 on Reader Service Card

AJAX Flexible Couplings

Give You a New Angle for Direct Connected Drives

AJAX ability to handle angular and offset misalignment totaling 7 degrees and more is preventing breakdowns, relaxing production tolerances, cutting assembly and maintenance costs. *Write for catalog.*

AJAX FLEXIBLE COUPLING CO. INC.
132 Portage Road Westfield, N. Y.
Incorporated 1920 Representatives in Principal Cities



WRITE FOR
FREE SAMPLE

... And Full Information
on How to Solve Difficult
Drive Pulley Problems

VAN Gorp
MFG., INC. Dept. PT
Pella, Iowa

NOW!

- Positive
Cleaning Action
- Less Wear
of Conveyor Belts

AT THE

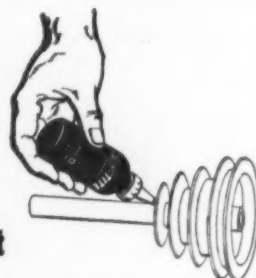
DRIVE END

with the NEW

"RUBBER LAGGED"

TURN-CLEAN
PULLEY

Simplify
and
speed
any shaft
assembly with
LOCTITE®



LOCTITE Sealant, "the liquid lock for metal parts," eliminates press fits, shaft distortion, keyways, set screws, etc., when assembling fans, pulleys, couplings, impellers, gears, rotors, armatures, etc. LOCTITE ends repairs and loosening caused by vibration. Simplify your production methods with LOCTITE Sealant.

Call your distributor, or write
for literature and free samples.

LOCTITE®

AMERICAN SEALANTS COMPANY

457 North Mountain Road, Hartford 11, Connecticut

Circle 127 on Reader Service Card

September, 1961

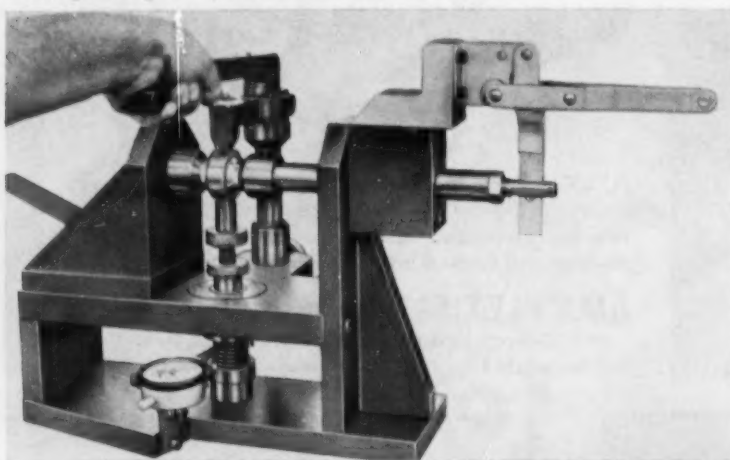
Circle 7 on Reader Service Card

PRODUCT NEWS

To get complete information on these products, use the Reader Service Cards bound into this issue.

Bearing test apparatus

A tester for measuring radial play in ball roller and self-aligning bearings. Easy to operate.



This tester checks radial play in anti friction bearings from 5 to 38 mm bore, with other models to 153 mm bore. For self aligning bearings, it handles sizes from $\frac{1}{4}$ in. bore to 1.50 in. bore, with other models taking up to a 6 in. bore. A spring pressure gauge shows a constant pressure reading for each bearing in increments of

one ten thousandths of an inch. It can be used for all types of bearings where there is an inner and outer race. Heavy duty frame, Dimensions—14 in. long by 12 in. wide and 12 $\frac{1}{2}$ in. high. Suitable for bench use in quality control. Southwest Products Co., Monrovia, Calif.

Circle 200 on Reader Service Card

Electric gear drive

Gear trains can be coupled selectively to output shaft through electromagnetic clutches.



The Electromat uses 90 volt DC clutches which rapidly engage or disengage to allow high cycle rates. Torque is adjusted by varying applied voltage for start, stop, forward and reverse, and multiple speeds. Drive motor runs continuously, thus decreasing inertia that must be decelerated and saving energy for rapid acceleration. Splash-lubricated bearings, gears and clutches, multiple-disc clutch faces. Six basic styles according to ratios and number of shafts. Ratios in 1, 2, 5, and 10 hp models from 9:1 to 0.5:1 forward, 3:1 to 0.5:1 reverse for three shafts; and 3:1 to 0.5:1 forward, 1:1 reverse, for two shafts. In the

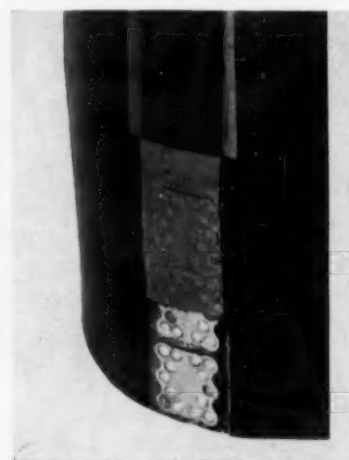
20 and 40 hp models, ratios from 4.4:1 to 0.48:1 forward, 2.8:1 to 0.48:1 reverse for three shafts; and 2.1:1 to 0.48:1 forward, 1:1 reverse for two shafts. Electronics Inc., Cleveland, Ohio

Circle 201 on Reader Service Card

Mechanical belt splice

Kits to make a rubber covered belt join. Splicing takes only 1 $\frac{1}{2}$ hours

Belt plates are attached after a simple countersinking operation and covered with a rubber strip. Resulting joint prevents fabric rot,

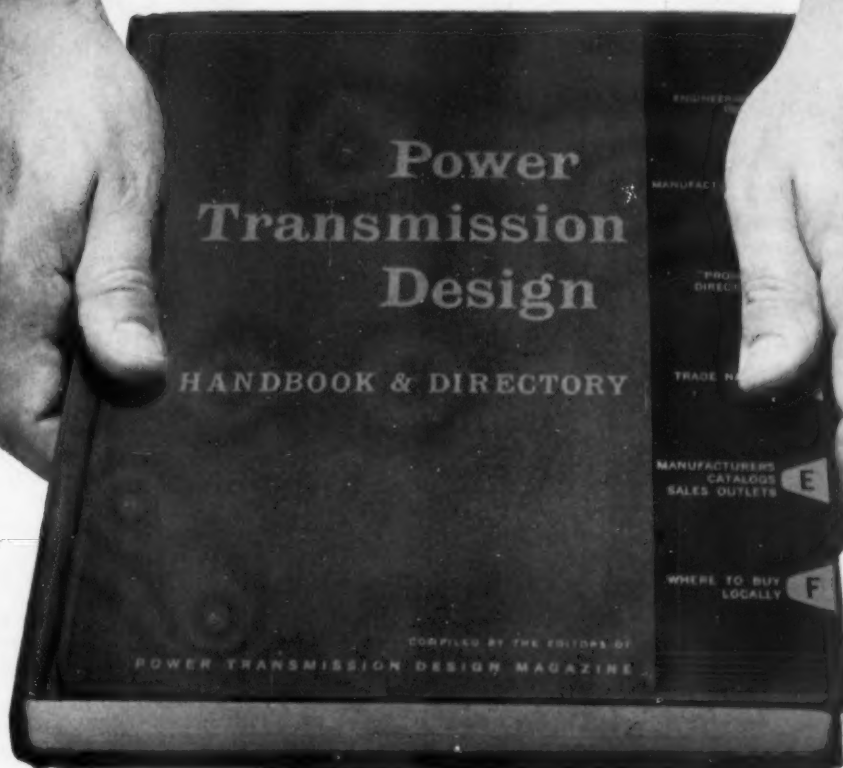


gives a cleaner scraper operation and cuts down wear on idler rollers. Photo shows the three steps to make the splice. Bottom: plates attached after the removal of the rubber cover. Center: rubber filler stock over the plates. Top: rubber plates covering plates and filler—cold vulcanized to the belt surface. The Crescent Fastener Co., Inc., New York, N. Y.

Circle 202 on Reader Service Card

Continued on page 54

Here are
the answers to
your power
transmission design
and specification
questions



More than 80,000 design engineers and buyers of power transmission products use this directory. It's their single source of design and specification data.

Price: \$12.00

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- Manufacturing Index
- Product Directory
- Trade Names
- Catalog Data
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Compiled by the editors of POWER TRANSMISSION DESIGN
An Industrial Publishing Corporation magazine
812 Huron Road • Cleveland 15, Ohio

WHAT MAKES *Alinabal* ROD ENDS BETTER?

One reason for the superior performance of Alinabal Rod Ends and Spherical Bearings is the precise control of the relationship of the spherical race to the ball.

Each Alinabal unit has a precision ground, through hardened steel race. Precise control of the race radius enhances low friction operation and prevents "end-loading" effects. This spherically ground race is manufactured for assembly around the ball, and is not a set of relatively soft, pressed inserts, nor is it a swaged housing. Moreover, loading slots are not used in the Alinabal construction method. Thus, the ball is positively and permanently retained under misaligning conditions.

Alinabal is the registered trade name for rod ends and spherical bearings manufactured under U.S. Patent 2,781,238.

A complete line — standard male and female rod ends — stud type rod ends — standard spherical bearings and rod linkages — sizes range from 3/16" to 4" bore.

SEND FOR
COMPLETE CATALOG

 split ballbearing
SBB DIVISION OF **MPB**
INCORPORATED
LEBANON, NEW HAMPSHIRE

Circle 126 on Reader Service Card

PRODUCT NEWS

Flat belt

For light duty conveying, elevating and power transmission.

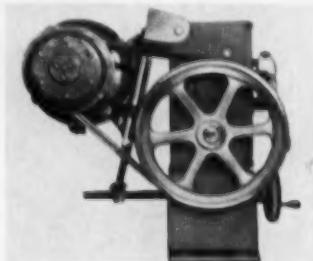
Made of woven cotton duck, it comes in 3, 4, 5, and 6-ply, with tensile strengths from 475 lb per inch of width for 3-ply stock to 1400 lb per inch of width for 6-ply stock. Cut widths up to 42 in. and lengths up to 500 ft. The belt is made endless by either hot or cold vulcanizing. Metal fasteners, including a non-sparking type, are installed on order. Friction surface is neoprene, with neoprene sealed edges. *Manheim Mfg. & Belting Co., Manheim, Pa.*

Circle 203 on Reader Service Card

Variable speed drive

Combines E-33-60 new model transmission with 3:1 variable pitch sheave.

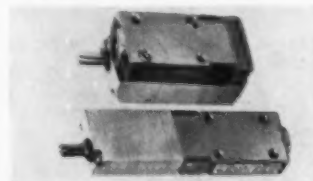
Claimed as the lowest priced variable speed drive anywhere, this assembly has a wide range and



maximum total ratio of 17:1. Advantages include a leakproof aluminum case, finger tip control, and only 10% by 6 in. floor space. *Turner Uni-Drive Co., Kansas City, Mo.*

Circle 204 on Reader Service Card

Ultra-miniature gearmotors



Provide up to 35 in. oz torque continuous duty, weigh only 2.5 oz.

Permanent magnet Type VS dc gearmotors come in two configurations: the end mounted reducer has

Don't let
"COUPLING IT IS"



Your Machines
of CONTINUOUS
PEAK PERFORMANCE

SPECIFY THOMAS FLEXIBLE COUPLINGS

Like a THIEF in the NIGHT an inferior coupling causes wear and damage to your machines—resulting in high maintenance costs and costly shut-downs.

Troublesome maintenance problems and down time are eliminated when you specify Thomas "All-Metal" Flexible Couplings to protect your equipment and extend the life of your machines.

UNDER LOAD and MISALIGNMENT only THOMAS FLEXIBLE COUPLINGS offer all these advantages:

- Freedom from Backlash
- Torsional Rigidity • Free End Float
- Smooth Continuous Drive with Constant Rotational Velocity
- Visual Inspection while in Operation
- Original Balance for Life
- Unaffected by High or Low Temperatures
- No Lubrication • No Wearing Parts
- No Maintenance

Write for our New Engineering Catalog 60

**THOMAS FLEXIBLE
COUPLING CO.**
WARREN, PENNSYLVANIA, U.S.A.

Circle 103 on Reader Service Card
POWER TRANSMISSION DESIGN

62 ratios from 7.88:1 to 25,573:65:1 and the side mounted reducer has 27 ratios from 26.93:1 to 2511.84:1. Spur gear system uses case hardened gears on hardened stainless steel shaft. Standard motor has 13 standard armatures for up to 50 vdc. Motor rated 0.0025 hp at 8000 to 17,000 rpm. Units meet appropriate MIL specs. *Globe Industries, Inc., Dayton, Ohio.*

Circle 205 on Reader Service Card

Ball bearing screw

Permits freewheeling at any position along its stroke.

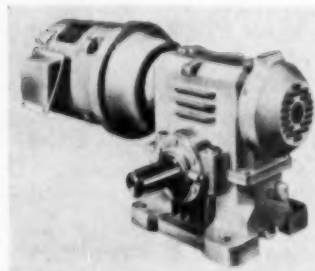
The ball nut halts at any position where the load reaches a preset amount. Two angular-contact



ball bearings and Belleville washers in a split housing are attached to the nut. Power is applied to the threaded end of the housing. By screwing the housing sections together or apart, the angular-contact bearing can be preloaded to the desired amount. Torque is transmitted through the preload unit to the ball nut. When load exceeds the preset amount, housing and nut will freewheel on the stud and screw. Full range of sizes (model shown has ball circle diameter of $\frac{1}{2}$ in. and outside diameter of 1 $\frac{1}{2}$ in.). Low-friction materials can be substituted for angular contact bearings. *Saginaw Steering Gear Div., General Motors Corp., Saginaw, Mich.*

Circle 206 on Reader Service Card

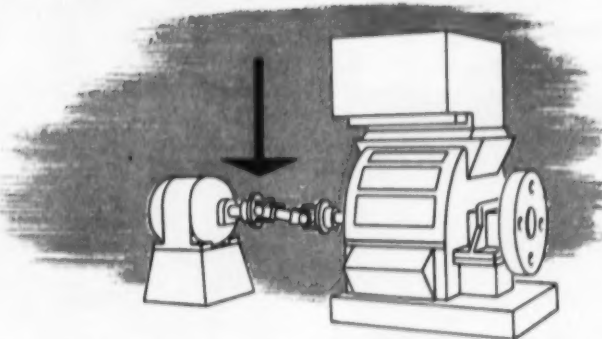
Motor reducer



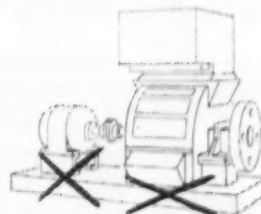
Involute helical thread form for easy installation and interchange of motors.

Delroyd reducers come in 8 sizes for any standard NEMA Type D flange motors, from one to 20

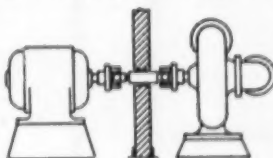
How to make "MISALIGNMENT" profitable with WATSON Drive Shafts



A WATSON drive shaft working at any angle from 1 to 8 degrees transmits power as efficiently as a flexible coupling, yet offers substantial savings in design engineering time and installation cost. Angles up to 20 degrees can be handled (depending on RPM). No painstaking axial alignment is required; simple, low-cost concrete foundations poured on the site replace costly unit base plates.



In addition, the use of Watson drive shafts offers:

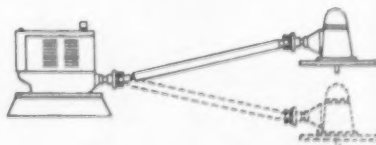


WIDEST LATITUDE IN LOCATION

of driving and driven elements for best utilization of space, distribution of weight, isolation of motor or engine, provision for maintenance or working space.

PROVISION FOR RELATIVE MOVEMENT

between driving and driven elements, either intentional or as a result of structural deflection or foundation shifts.



WATSON drive shafts are promptly available in 9 sizes, 10 to 800 h.p., for speeds to 4,000 r.p.m. and more. Why not get the facts—now? New 8-page Engineering Data Bulletin F-15a is yours for the asking; please address Dept. 150



H. S. WATSON COMPANY

1316 - 67th Street • Emeryville 8, California
1606 Laskey Road • Toledo 12, Ohio

PRODUCT NEWS

hp, with center distances from 2½ to 8 in., and speed ratios of 5:1 to 70:1 and higher. Either single or double extended gear shafts. Centrifugally cast gearing is generated to produce leaving side contact, which allows an entering side gap for lubricant. Motor and worm shaft couplings need no lubrication. *De Laval-Holroyd, Inc., Trenton, N. J.*

Circle 207 on Reader Service Card

Belt repair fasteners



For fast repairs in all types of flat belting.

You just hammer in these 3-Point fasteners with the new Persuader tool to fix rips or tears in rubber,

synthetic or cotton belting. A wide variety of sizes available for belting from 1/16 to 3/16 in. thick. *Flexible Steel Lacing Co., Chicago, Ill.*

Circle 208 on Reader Service Card

Miniature bearings

Lower priced precision line for less exacting applications.

Called Value Precision, the new line offers tolerances to ABEC-5 (+.0000 —.0002 in. on bore and outside diameter) Specifications show a standard radial play range of .0002 to .0005 in. *The Barden Corp., Danbury, Conn.*

Circle 209 on Reader Service Card

Variable speed drive



Uses standard components.

The 410 Horizontal Countershaft assembles components into 3, 5, 7½ and 10 hp drives.

Ratios up to 8:1. The motor mounts at either side of the Countershaft. Either manual or automatic regulators control speeds. The assembled drive may be installed at floor, wall or ceiling. Shaft may be horizontal or vertical. *Lewellen Mfg. Co., Columbus, Ind.*

Circle 210 on Reader Service Card

Servo actuator



Clutch type, has high degree of precision with relatively low power.

Developed for computer and missile applications the Series 3170

HORTON



NEW AIR-CHAMP BRAKES* STOP SURE!

For stopping rotating parts! PANCAKE DESIGN takes less room—MOUNT ANYWHERE—torque arm or universal. 3 low-inertia models handle up to 4,300 inch lbs. torque. FORCED DRAFT COOLING dissipates heat fast; remote friction surface position guards against heat buildup and brake "fade." Control with static air pressure. Low cost! Ask about "Air-Champ" clutches! Write for brochure!

*Patent pending



HORTON MANUFACTURING CO., INC.
1179 15th Ave. S.E., Minneapolis 14, Minn.

HORTON

Circle 59 on Reader Service Card

REPRINTS

The following reprints of feature articles from **POWER TRANSMISSION DESIGN Magazine** are available:

ELECTRIC MOTORS

Covers ac and dc types. Tables show who makes what. From Nov., Dec., 1960 and Jan. 1961 issues. Thirty-two pages.

1-9 copies \$1 each
10-49 copies 75c each
Over 50 copies, 50c each

CLUTCHES AND BRAKES

An introduction to both friction and positive contact types. From June and July 1960 issues. Sixteen pages.

1-9 copies, 75c each
10-49 copies, 50c each
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GEARMOTORS

Put the power where the work is—with a gearmotor. From Jan. 1960 issue. Twelve pages.

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ELECTRICAL SPEED ADJUSTMENT

Tells how to adjust your speed, any speed, precisely, electrically. Sixteen pages.

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NOMOGRAMS

Six nomograms for complete mounting of pivoted motor, base and accessories.

Copies 15c each

Send all orders—enclosing the exact amount in coins or checks—to: **POWER TRANSMISSION DESIGN, 812 Huron Road, Cleveland 15, Ohio.**

servo provides high frequency response, high torque output and proportional torque control. Torque range from 1 to 70 in. lb. Corresponding speed range of from 285 to 4.6 rpm, is obtained by varying the gear reduction package on the building block principle. A companion amplifier measuring $2\frac{1}{2} \times 2\frac{1}{2} \times 2$ in. has been developed to drive the servo. *Lear, Inc., Electro-Mechanical Div., Grand Rapids, Mich.*

Circle 211 on Reader Service Card

Shaft seals

Contain both stationary seal face and positive-drive mating ring factory-assembled as one unit.

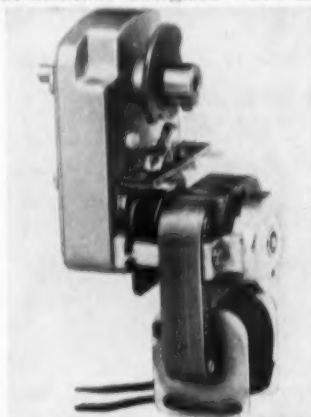
Three types of these unitized face seals are available. Type 66 is claimed as the first unitized seal that can take pressures up to 250 psi, speeds up to 10,000 fpm, and temperatures from -65 F to 400 F. Types 46 and 48 are lower in cost with these recommended operating ranges: pressures to 10 psi, speeds to 3500 fpm and temperatures from -20 F to 250 F. *Gits Bros Mfg. Co., Chicago, Ill.*

Circle 218 on Reader Service Card

Damper control motor

Provides complete cycle function plus positive control.

The gearmotor, which incorporates cam, switch and brake, is automatically energized when the



blower is turned on. The louvers are opened by this motor instead of by the force of air from the blower. The brake stops the motor quickly without coasting and holds the louvers in an open position. When the blower is turned off, the motor is energized again, going through another part of a revolution and closing the louvers tight. For such

applications as opening doors etc. *Brevet Products Corp., New York, N. Y.*

Circle 219 on Reader Service Card

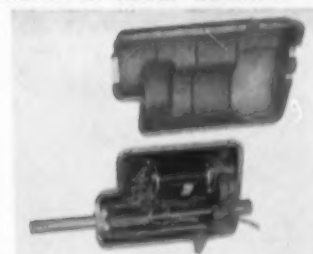
Tiny gear clamps

Balanced type sub-miniature clamps.

Standard bore size is $\frac{1}{8}$ in. Also in stock are more than 150 different types of instrument clamps with tolerances of ± 0.001 , in shaft sizes of $\frac{1}{8}$, $\frac{1}{4}$, $\frac{3}{16}$ and $\frac{5}{16}$. *Siamco Div., Tech Ohm Electronics, Long Island City, N. Y.*

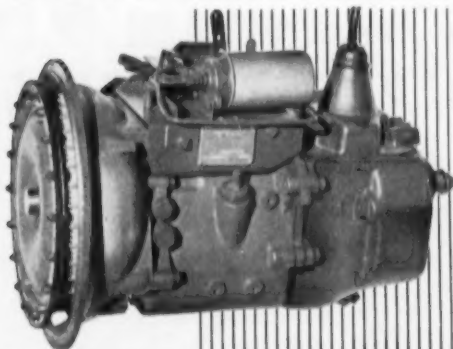
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Industrial linear actuator



Features positioning accuracy to within ± 0.0025 in. without feed-back.

Model C402 heavy duty actuator has a rated thrust of 500 lb



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On this Getman Scoot-Crete ore carrier, a FUNK Revers-O-Matic® Drive installation delivers smooth, instant power shifting — forward and reverse — with just one foot pedal. And a FUNK TORQUE CONVERTER automatically adjusts power to speed and load requirements, eliminates wheel spinning.

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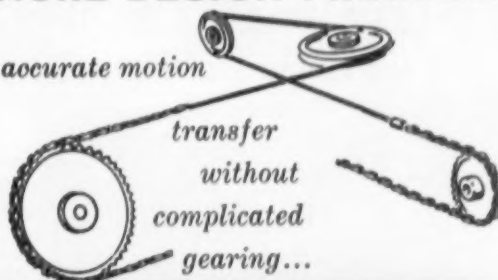
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Provide precise, positive motion transfer through several planes simultaneously with no cable slippage...no complicated gearing. Unlimited center-to-center selection for miniature and sub-miniature assemblies in servo systems, gyro systems, special cameras, electronic equipment, and small precision instruments. Less weight, cost, maintenance — wider tolerances. Designed to operate around minimum 7-tooth sprocket with root diameter of .250 inches. Chain pitch .1475 inches; Weight .45 oz. per lineal ft. Material: stainless steel, or other materials.

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Circle 94 on Reader Service Card

PRODUCT NEWS

tension and compression, with a maximum thrust of 1000 lb tension and compression. It also has a continuously adjustable stroke of from 0 to 6 in. with an optional potentiometer for position indication, a capacitor start-and-run and a reversible single phase motor with integral brake. Entirely enclosed, with all ball bearings and gears lubricated for life. Includes emergency hand operation. *Lear Inc., Grand Rapids, Mich.*

Circle 221 on Reader Service Card

Shaft clamp



Has nylon insert for better grip.

Clamps are available in $\frac{1}{8}$, $\frac{1}{4}$ and $\frac{3}{16}$ in. shaft sizes. The eighty-five types cover balanced, un-

balanced, gear, hinged, pull and swivel clamps. Precision manufactured to 0.001 in. The nylon tends to flow into hub grooves which makes a better gripping surface and prevents marring of shafts and hub. *Sterling Instrument Div., Designatronics Inc., Port Washington, N. Y.*

Circle 212 on Reader Service Card

New 400 cycle motor



Interchangeable with 60 cycle motors.

This 12-pole partial motor comes in standard NEMA sizes and specifications. Stator diameters available are 4.44, 5.48 and 6.29 in. Light weight materials, cast aluminum rotor and Freon resistant windings. *U. S. Electrical Motors Inc., Los Angeles, Calif.*

Circle 213 on Reader Service Card

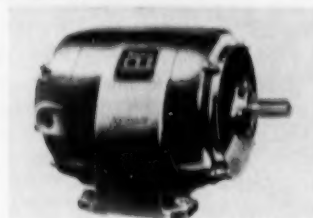
Plastic journal bearings

Work efficiently to 600 F and down to cryogenic temperatures.

Bearings are made from Duroid 5813, a high lubricity reinforced Teflon. Dirt or fibers will not stick to them. They can be bonded to metal or used without a metal backing in new designs. Important properties are: thermal expansion equivalent to aluminum, no cold flow, and no effect by moisture on dimensions. Available in usual sizes. *Rogers Corp., Rogers, Conn.*

Circle 214 on Reader Service Card

Single phase motors



Built to NEMA standards, for general purpose jobs.

Drip-proof type DK are capacity start, induction run, squirrel cage motors that have a centrifugal

STEPLESS VARIABLE SPEED

SETS AND RESETS ACCURATELY



PRECISION CONTROL

This Zero-Max screw control gives exact speed settings. It is one of many options from the standard lever type control.

Zero-Max drives deliver constant torque, are truly stepless—zero to maximum—available with instant reverse and neutral. They are low cost, small in size but big in power and performance. Over 30 basic hp models (1/15 to 3/4 hp) carry torque ratings of 3 to 450 in. lbs. and speed ranges to 0 to 1200 rpm. Drives come with or without motors and gearheads.

Send for free catalog and name of your nearest representative.

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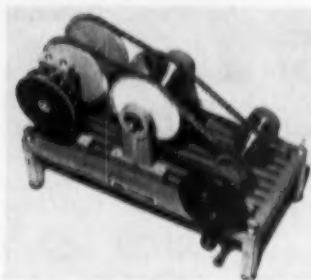
Circle 34 on Reader Service Card

POWER TRANSMISSION DESIGN

switch to disconnect the auxiliary starter winding and capacitor from the line as the motor accelerates to full speed. Features axial ventilation, totally enclosed and dust-proof centrifugal switch, removable built-in capacitors. Also an optional manual or automatic reset thermal overload protective device. Hp ratings from 1 to 5 hp. *Newman Electric Motors Inc., Newark, N. J.*

Circle 215 on Reader Service Card

Miniature pitch chains



Type 18-8 stainless steel chain for servomechanisms etc.

This 0.1475 pitch chain is stocked in lengths from 5.900 to 57.525 in. (special lengths available). Pin type hub sprockets have 1/8, 3/16 and 1/4 in. shaft sizes.

Hubless type sprockets in 1/2 in bore size. Sprockets can be made of aluminum, linen, phenolic or nylon. *PIC Design Corp., East Rockaway, L. I., N. Y.*

Circle 216 on Reader Service Card

Motor brake



For direct shaft attachment to NEMA motor frames 56C60C, 182C, and 184C.

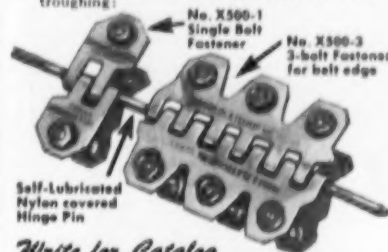
The L-60 Universal series of 1 1/2 and 3 ft.-lb torque brakes fits the frames without modification of brake or motor. The wrap-around cover permits vertical wall or ceiling mounting. External manual release trip for remote control. Hub or thru-shaft mounting. *Dings Brakes Inc., Milwaukee, Wis.*

Circle 217 on Reader Service Card

Circle 10 on Reader Service Card



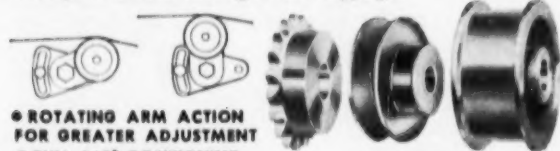
Recommended for mines, quarries, construction work, storage yards — wherever belts length must be frequently changed. Hinged Plategrip Fasteners make a strong, flexible joint in heavy duty conveyor belts, trough naturally, ride smoothly over pulleys, yet can be separated by simply pulling the hinge pin. Improved design takes the new smaller diameter self-lubricating nylon sheathed cable hinge pins, No. X500-1 single bolt fasteners and No. X500-3 3-bolt fasteners (used at outside edges) to reinforce edges and aid troughing:



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5328 NORTHWEST HIGHWAY • CHICAGO, ILLINOIS



Controlled tensioning eliminates shock loading through excessive chain vibration, and horsepower loss through belt slippage.



- ROTATING ARM ACTION FOR GREATER ADJUSTMENT
- FULL 360° POSITIONING

A low cost tensioner for single and multiple width drives that is more adaptable to machine frames. See your Power Transmission Distributor or write...

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18 SIZES
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1441 N. 2nd St. St. Louis 6, Mo.

Circle 20 on Reader Service Card

September, 1961

ROTO-GUARD

MOTION INDICATOR

SHAFT MOTION INDICATOR

PROTECTS MACHINERY BY INDICATING STOPPAGE DUE TO OVERLOADING OR MALFUNCTION

A and B: On end return idlers, warn if conveyor should break, slow or stop.

C: On boot pulley, signals slowdown, stoppage, slippage due to overload, boot pulley out of adjustment. Helps prevent fires.

D: On screw conveyor, warns of slowdown due to overloading. Prevents damage.

E: On rotary feeder, warns of slowdown; prevents plugging damage.

Roto-Guards can be wired into interlock system; stoppage of one component automatically stops others; prevents damage.

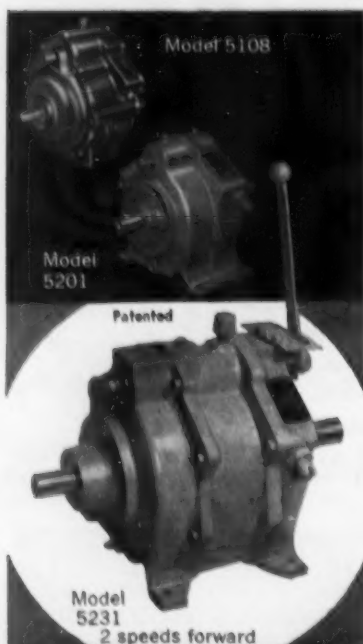
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S-N REVERSING TRANSMISSIONS

5 models 8 and 28 h.p.
with power packed
versatility



S-N Reversing Transmissions are performance proven, space-saving single units which reverse under full load. Adaptable to the design or redesign of a wide variety of industrial equipment. For technical data write The Snow-Nabstedt Gear Corp., Hamden, Conn.

SPECIFICATIONS

Model No.	5231	5201	5108
Reduction Forward	1.97:1 3.34:1	3.16:1	3.75:1
Ratio Reverse	3.37:1	3.16:1	3.75:1
Power Up To	28 HP	28 HP	8 HP
Max. Input Torque in. lbs.	1000	1000	320
Max. Input Speed RPM	2400	2400	2400
Dimensions	Long 15 1/8" Wide 14" High 14 1/4"	11 1/2" 13 1/2" 14 1/4"	9 1/8" 10" 10 1/4"



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Industrial Division
Transmission Engineers
For Over Half a Century

Circle 97 on Reader Service Card

LITERATURE

on drives and components

To get free copies of the following literature, use the Reader Service Cards bound into this issue.

Index ASTM data

This 62-page booklet lists the symposiums, manuals, special publications, indexes, compilation of standards, charts, reference photos and reports published by the American Society for Testing Materials. Describes more than 300 items, 40 of which were not previously listed. Covers all phases of materials and their evaluations, arranged by titles and subjects. *American Society for Testing Materials*, 1916 Race St., Philadelphia, Pa.

Circle 300 on Reader Service Card

V-belt wall chart

Chart shows how to install the Veelos adjustable V-belt. Comparative length tables list lengths in inches for equivalent sizes of fractional hp endless V-belts, sizes 3L140 through 5L1000, and for industrial endless V-belts sizes A26 through E660. Gives directions for measuring, coupling and installing. *Manheim Mfg. & Belting Co.*, Manheim, Pa.

Circle 301 on Reader Service Card

Trailer axles

Twelve-page folder describes 3 new series added to the TK Series, making a complete line of related-design trailer axles. The new axles cover a capacity range from 14,000 lb to 30,000 lb. Folder rounds out tabulated data with many photos and drawings. *Rockwell-Standard Corp.*, Transmission & Axle Div., Detroit, Mich.

Circle 302 on Reader Service Card

Flexible cushion couplings

Bulletin 901B, 24 pages, features the expanded line of Para-flex Flexible Cushion Couplings. Includes details of the new PX280 coupling and the PX90 intermediate size. Product photos, drawings, and installation pictures illustrate

standard, high speed and flywheel types. Lists prices and gives hp ratings, dimensions and weights. *Dodge Mfg. Corp.*, Mishawaka, Ind.

Circle 303 on Reader Service Card

Spiral bevel reducers

Bulletin J-25 cites the advantages of spiral bevel design and includes information on: basic types, special features of vertical types, applications, selection procedure, over-hung and thrust load capacities, hp and thermal ratings and backstop selection. Many charts and illustrations. *Jones Machinery Div.*, Hewitt-Robins, Stamford, Conn.

Circle 304 on Reader Service Card

Thin section bearings

Revised Bulletin S-132 lists the 90 sizes of Reali-Slim bearings for off-the-shelf delivery. These Type CP bearings have Conrad deep groove ball radial construction and range in size from 4 to 12 in. bore with 1/4 to 1 in. width and cross section. Prices and specifications. *The Kaydon Engineering Corp.*, Muskegon, Mich.

Circle 305 on Reader Service Card

Gasket materials data

Brochure AD-190 tells you how to choose the right gasketing material and what a correct gasket design is. Details resistance rating for 120 fluids and gases. Technical data charts show qualities, uses, of various materials, including the new material, Viton. *Garlock Inc.*, Palmyra, N. Y.

Circle 306 on Reader Service Card

Starter enclosures

Bulletin GEA-7324 describes stainless steel enclosures for watertight applications of manual and magnetic motor starters up to 200 hp, 600 volts. *General Electric Co.*, Schenectady, N. Y.

Circle 307 on Reader Service Card

Manual details clutch/brake units

Manual 361, 60 pages, is to assist engineers in the selection and application of electro-magnetic clutches and brakes, mechanical clutches, torque indicators, torque standards and multi-speed transmissions. Specifications and schematics on 354 standard clutch/brake units. Also has sections on facilities and custom designing. Autotronics Inc., Florissant, Mo.

Circle 308 on Reader Service Card

Bronze cased rods

In combination with hardened steel bushings bronze-cased piston and guide rods are said to have greatly increased wear life. Bulletin lists advantages specifications, and sizes. Thomson Industries, Inc., Manhasset, N. Y.

Circle 309 on Reader Service Card

Rotary torque actuator

Bulletin RA-500 highlights an improved rotary torque actuator which provides 0-370 degrees of high torque rotation. It can be

powered by air, gas, water, or oil and may be stopped at any point in the rotation cycle. Full data, graphed torque ratings and details of an integral hydraulic rotary power package. Carter Controls, Inc., Lansing, Ill.

Circle 310 on Reader Service Card

Flexible couplings

Bulletin No. 10 highlights design advantages of flexible couplings and a newly designed coupling cover. Lists standard prices and sizes. Also covers flexible couplings with fixed bores and flexible couplings with plain bores for re-boring. Acme Chain Corp., Holyoke, Mass.

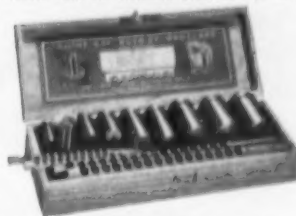
Circle 311 on Reader Service Card

Set screws

How a set screw works and why it often doesn't is the subject of an illustrated pamphlet that reviews the line of Unbrako high-torque socket set screws. Illustrations include microphotos of grain structures and tabulations of holding power. Standard Pressed Steel Co., Jenkintown, Pa.

Circle 312 on Reader Service Card

Circle 124 on Reader Service Card



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KEYWAY BROACH KIT

Money saver, too. We cut keyways (1/16" to 1") in any bore from 1/4" to 3" in one minute for as little as one cent per keyway. That kit has paid for itself a dozen times over.

Minute Man® square, hexagonal and round broaches, as well as Production Types save time and money, too. For complete information, mail the coupon.

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Same bushing fits sprockets of many diameters. Drive speed changes made quickly, easily, saving time and cost. Same bushing used with Fort Worth QD Sheaves. Distributors give immediate delivery. No re-boring. No delay. Also Types A, B and C Sprockets and Roller Chain. Write for NEW Sprocket Catalog 320.

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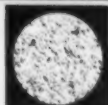
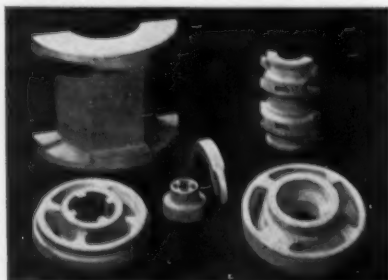
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BEARIUM METAL's amazing superiority is due to the uniform dispersion of microscopic lead particles within the copper-tin grains rather than between the grain boundaries as found in ordinary bronzes. Result is that it will not seize or score the shaft nor will it melt out like babbitt—even in applications where a liquid other than oil must be used as the lubricant.

If you have a bearing application calling for dependable, trouble-free performance, by all means BEARIUM METAL is your best buy in bearing bronze. Try it on one of your toughest jobs. You'll be glad you did!



Bearium Metal Ordinary Leaded Bronze

FEATURES: Non-Seizing and Non-Scoring • Long-Wearing • Self-Lubricating • Low Coefficient of Friction • High Compressive Strength • Resistant to Shock Loads • Sound, Uniform Structure.

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Circle 128 on Reader Service Card

MEN

of the power transmission field

Conlon named sales VP of Dayco's Rubber Div.



Conlon

Joseph A. Conlon has been named vice president, sales, of the Rubber Products Div. of Dayco Corporation. He takes over from Robert G. Burson, who resigned to accept another position.

Conlon joined Dayco to fill a newly created position of marketing manager. He was responsible for co-ordinating sales, distribution and merchandising.

He began his career in 1933 as an industrial sales engineer with U. S. Rubber Co., after taking specialized courses in plastics and rubber technology at California Institute of Technology. He was a vice president of one of the U. S. Rubber's subsidiaries before joining Dayco.

Joins Falk's Cincinnati office

Keith Mottet joins the Cincinnati office of the Falk Corp. He will work under Kenneth W. Morrissey with a territory that covers nine Ohio counties.

Mottet is a graduate of the University of Minnesota.

Powell elected president of James McGraw, Inc.



Powell

Claiborne F. Powell was elected president and chairman of the Board at a recent meeting of the Directors of Jas. McGraw Inc. He succeeds Hunter T. Wagener, who is retiring after 40 years with the mill supply firm. Wagener will continue as company advisor.

Powell first joined McGraw in 1927. He left to enter the oil business, and was half owner of the Cavalier Oil Co. for several years. He rejoined the McGraw sales staff in 1954 and was elected vice president and director in 1958.

New marketing services director for Eaton

Edgar W. Clark, formerly director of marketing research for Eaton Mfg. Co., now moves up to the newly-created post of director of marketing services. He will supervise and co-ordinate all of Eaton's marketing activities in advertising, sales, product promotions and research.



Clark



Gustafson

Michigan Tool advances two in Cone Drive Div.

Paul N. Gustafson, assigned to manage the Cone Drive Gears Div. of Michigan Tool Co., succeeds Fred E. Birtch who has retired after 28 years with the company.

Gustafson moved from sales engineering to superintendent of the Cone Drive Detroit plant in 1947, and became plant manager of the Traverse City plant in 1950.

Warner Electric appoint R&D supervisor

Siegfried Nuber is the new supervisor—research and development at Warner Electric Brake & Clutch Co.

A native of Argentina, Nuber came to the U. S. in 1957. He worked at the Ford Motor Co. as a research engineer until August

1959, when he joined the Warner Electric research department. He holds a Master's Degree in electrical engineering from Buenos Aires University.



Nuber



Burson

New executive appointed at Foote Bros

Robert G. Burson, former vice president of Dayco, is the new director of marketing, Industrial Products of Foote Bros Gear & Machine Corp.

Burson brings fifteen years of industrial sales and marketing experience to his new post. His capabilities will be extremely valuable in the company's accelerated marketing program, said president J. R. Fagan. He will make his headquarters at Foote's executive offices in Chicago.

Circle 33 on Reader Service Card

ELIMINATE BREAKDOWNS due to OVERLOADING



Ideal for use in conveyors, presses, farm machinery, construction equipment, material handling machines and applications of power transmission equipment.

- ALL STEEL CONSTRUCTION
- FEWER PARTS
- TORRINGTON NEEDLE BEARINGS LUBRICATED FOR LIFE

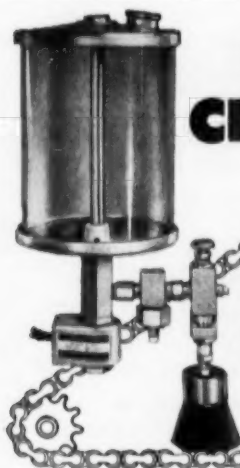
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Here's the low-cost answer to chain breakdowns caused by link-wear, stretch, corrosion and friction. OIL-RITE Chain Oilers feed oil by gravity through solenoid and sight feed valve to brush which rides the chain. Solenoid starts and stops with driving motor, making operation automatic, oiling only when chain moves. Drop feeding adjustable. 9 oz. — 1 gal. in capacity with brushes to suit your chains.

GIVE YOUR PLANT ALL THESE BENEFITS!

- Safe, sure chain lubrication
- Reduce chain wear
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Many styles of Electro and Manual Chain Oilers available. Write for Free Bulletin.

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Circle 79 on Reader Service Card

September, 1961

GEAR LABORATORY SERVICE

the **RED RING**
GEAR LABORATORY
offers you:

- Research and development
- Consultation on gear practice
- Experimental prototypes
- Machining
- Tooling
- Finishing
- Heat treating
- Inspection
- Pilot runs
- Moderate production runs

You are assured
of our careful
attention and
prompt action.

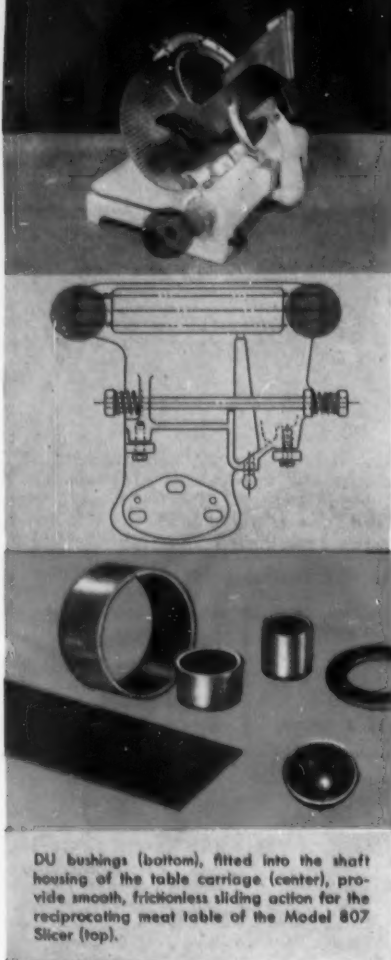
**NATIONAL BROACH &
MACHINE COMPANY**

5600 ST. JEAN • DETROIT 13, MICHIGAN
World's Largest Producer of Gear
Shaving and Honing Equipment



Circle 77 on Reader Service Card

EXAMPLE #6



DU bushings (bottom), fitted into the shaft housing of the table carriage (center), provide smooth, frictionless sliding action for the reciprocating meat table of the Model 807 Slicer (top).

DU* DRY BEARINGS Solve Another Problem

"The meat table of the Model 807 Gravity-Feed Slicer is guided by a combination of twin rollers and a round slide bar for reciprocating action. The use of DU Dry Bushings, due to their low coefficient of friction, has solved the problem of providing a table with exceptionally smooth operating qualities."

Paul H. Meyer
Project Engineer
U.S. Slicing Machine Co., Inc.

The switch to DU bushings, in place of bronze, has given U.S. Slicing Machine Company an easier operating slicer, with complaints practically eliminated. DU bushings have proved to operate smoothly at an average bearing load of 25 p.s.i. on slicers requiring an average annual usage of 5,000 hours and a service life of five years.

DU bearings are ideal for many applications. They withstand much higher velocities, run much cooler at lower speeds than other unlubricated bearings . . . have a compressive strength of 51,000 p.s.i. DU bearings are applied without the need for temperature-limiting adhesives . . . will withstand from -450°F to +536°F.

GARLOCK

Apply DU dry bearings to appliances, automobiles, aircraft, farm and industrial machinery, office equipment. Standard bushings and thrust washers available for 1/4" to 5" shafts; thrust washers for 3/8" to 2" shafts; hemispherical cups from 5/8" to 1 1/2"; strip available for special fabrication. Write for engineering catalog DU-458. Special Products Dept., Garlock Inc., P. O. Box 612, Camden 1, New Jersey.

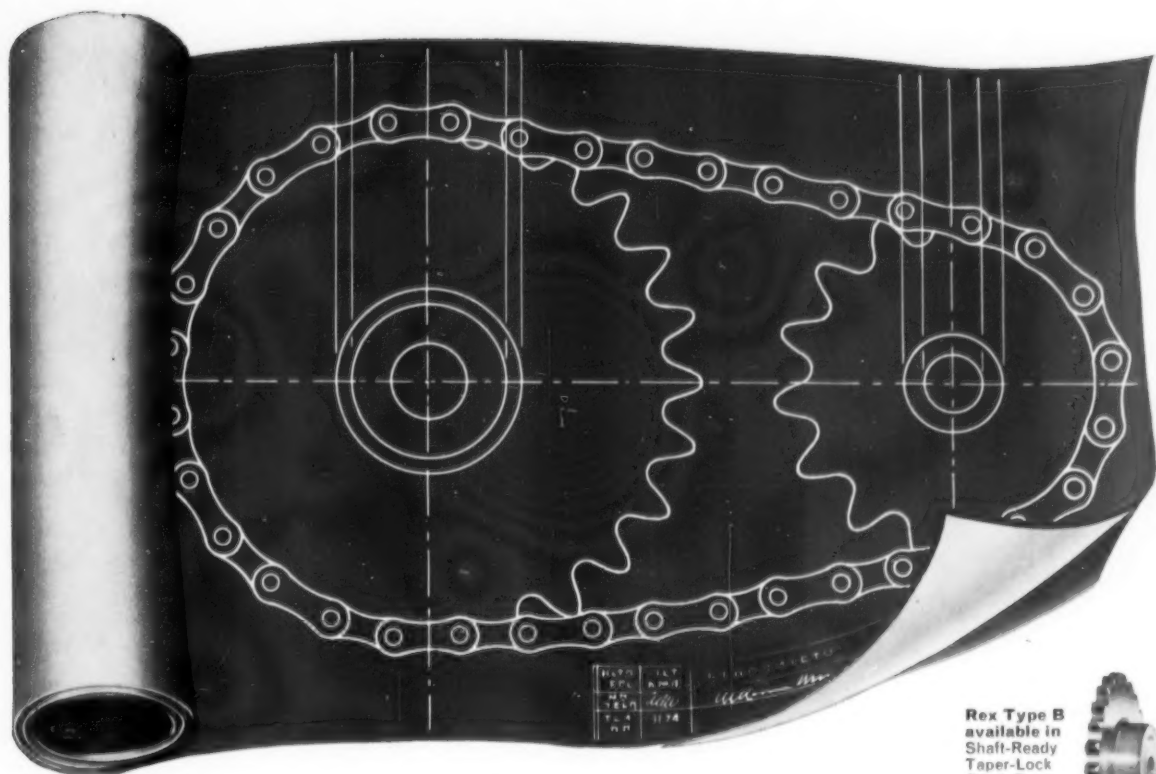
*Trademark, Glacier Metal Company, Ltd.



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